A CROSS SECTIONAL STUDY TO ESTIMATE THE PREVALENCE OF OCCULT SPINAL DYSRAPHISM USING ULTRASOUND IN CHILDREN AGED BELOW 2 YEARS FOR UROGENITAL AND ANORECTAL SURGERIES IN OPERATING ROOM OF A TERTIARY CARE HOSPITAL

A dissertation submitted to the Tamil Nadu Dr. M. G. R. Medical University, Chennai in partial fulfilment of the requirement for the MD Anaesthesiology (Branch X) degree examination to be held in April 2017.

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Dissertation submitted to the

THE TAMIL NADU DR. MGR MEDICAL UNIVERSITY, CHENNAI

In partial fulfilment of the requirements for the degree of

MASTER OF MEDICINE

IN

ANAESTHESIOLOGY

By

NOVIN CHACKO JOHN

Register number: 201520357

DEPARTMENT OF ANAESTHESIOLOGY

CHRISTIAN MEDICAL COLLEGE

VELLORE

APRIL 2017

CERTIFICATE

This is to certify that "**A CROSS SECTIONAL STUDY TO ESTIMATE THE PREVALENCE OF OCCULT SPINAL DYSRAPHISM IN CHILDREN AGED BELOW 2 YEARS FOR UROGENITAL AND ANORECTAL SURGERIES USING ULTRASOUND IN OPERATING ROOM OF A TERTIARY CARE HOSPITAL"** is the bonafide work of Dr. Novin Chacko John under my supervision in the Department of Anaesthesia, Christian Medical College Vellore in partial fulfilment of the requirements for the M.D Anaesthesiology Examination Branch X of the Tamil Nadu Dr. M.G.R Medial University to be held in April 2017 and no part thereof has been submitted for any other degree.

Dr. Ekta Rai MD, MRCA

Professor, Department of Anaesthesiology

Christian Medical College,

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CERTIFICATE BY THE HEAD OF THE DEPARTMENT& PRINCIPAL

This to certify that This is to certify that "**A CROSS SECTIONAL STUDY TO ESTIMATE THE PREVALENCE OF OCCULT SPINAL DYSRAPHISM IN CHILDREN AGED BELOW 2 YEARS FOR UROGENITAL AND ANORECTAL SURGERIES USING ULTRASOUND IN OPERATING ROOM OF A TERTIARY CARE HOSPITAL"** is the bonafide work of Dr. Novin Chacko John under the supervision of Dr. Ekta Rai MD MRCA, Professor of Anaesthesiology in the Department of Anaesthesia, Christian Medical College Vellore.

Dr. Sajan Philip George
Professor and Head
Department of Anaesthesiology
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Dr Anna P Pulimood
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DECLARATION

I, Novin Chacko John, do hereby declare that the dissertation titled "**A CROSS SECTIONAL STUDY TO ESTIMATE THE PREVALENCE OF OCCULT SPINAL DYSRAPHISM IN CHILDREN AGED BELOW 2 YEARS FOR UROGENITAL AND ANORECTAL SURGERIES USING ULTRASOUND IN OPERATING ROOM OF A TERTIARY CARE HOSPITAL"** is a genuine record of research done by me under the supervision and guidance of Dr Ekta Rai, Professor, Department of Anaesthesiology, Christian Medical College, Vellore and has not previously formed the basis of award of any degree, diploma, fellowship or other similar title of any university or institution.

Vellore Dr. Novin Chacko John

Date : September 25th 2016

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A cross sectional study to estimate the prevalence of occult spinal dysraphism in children aged below 3 years requiring urogenital and anorectal surgeries using ultrasound in a tertiary care hospital.
Dr Novin Chacko John, Emp. No: 21034, PG Registrar, Anaesthesia Dr Ekta Rai, Emp. No: 30975, Anaesthesia, Dr. Justin James, Anaesthesia Dr Jyoti Panwar, Emp. No: 31535, Professor, Department Of Radiology, Dr. Antonisamy, Emp. No: 3090, Prof & Head, Department of Biostatistics..

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The Institutional Review Board (Silver, Research and Ethics Committee) of the Christian Medical College, Vellore, reviewed and discussed your project titled "A cross sectional study to estimate the prevalence of occult spinal dysraphism in children aged below 3 years requiring urogenital and anorectal surgeries using ultrasound in a tertiary care hospital" on November 18th 2015.

I enclose the following documents:-

1. Institutional Review Board approval 2. Agreement

Could you please sign the agreement and send it to Dr. Nihal Thomas, Addl. Vice Principal (Research), so that the grant money can be released.

With best wishes,

Dr. Nihal Thomas
Secretary (Ethics Committee)
Institutional Review Board

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The Committee reviewed the following documents

1. IRB Application format
2. Patient Information Sheet and Informed Consent Form (English, Tamil, Hindi, Telugu, Malayalam)
3. Proforma
4. Cvs of Drs. Novin Chacko John, Ekta Rai, Jyoti Panwar
5. No.of documents 1- 11

The following Institutional Review Board (**Silver**, Research & Ethics Committee) members were present at the meeting held on November 18th 2015 in the CREST/SACN Conference Room,Christian Medical College, Bagayam, Vellore 632002.

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Mrs. Pattabiraman	BSc, DSSA	Social Worker, Vellore	External, Lay person
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Dr. Shirley David	MSc, PhD	Professor, Head of Fundamentals Nursing Department, College of Nursing, CMC, Vellore	Internal, Nurse

We approve the project to be conducted as presented.

Kindly provide the total number of patients enrolled in your study and the total number of withdrawals for the study entitled: "A cross sectional study to estimate the prevalence of occult spinal dysraphism in children aged below 3 years requiring urogenital and anorectal surgeries using ultrasound in a tertiary care hospital" on a monthly basis. Please send copies of this to the Research Office (research@cmcvellore.ac.in)

Fluid Grant Allocation:
A sum of 50,000/- INR (Rupees Fifty Thousand) will be granted for 1 year and out of which a maximum of Rs.5000/- can be spent for stationery, printing, Xeroxing and computer charges(if computers used are within the institution).

Yours sincerely

Dr. Nihal Thomas
Secretary (Ethics Committee)
Institutional Review Board
IRB Min No: 9760 [OBSERVE] dated 18.11.2015

Dr. NIHAL THOMAS
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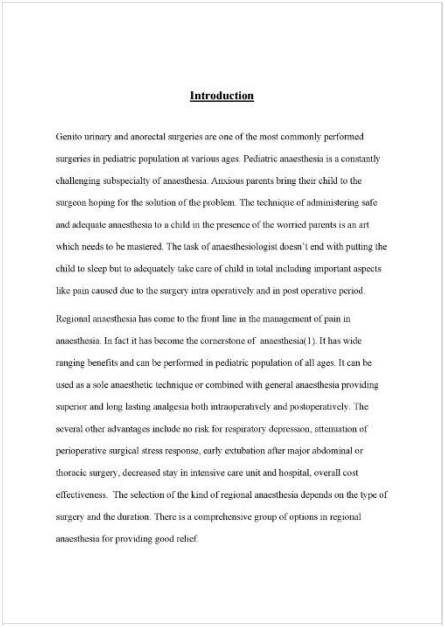
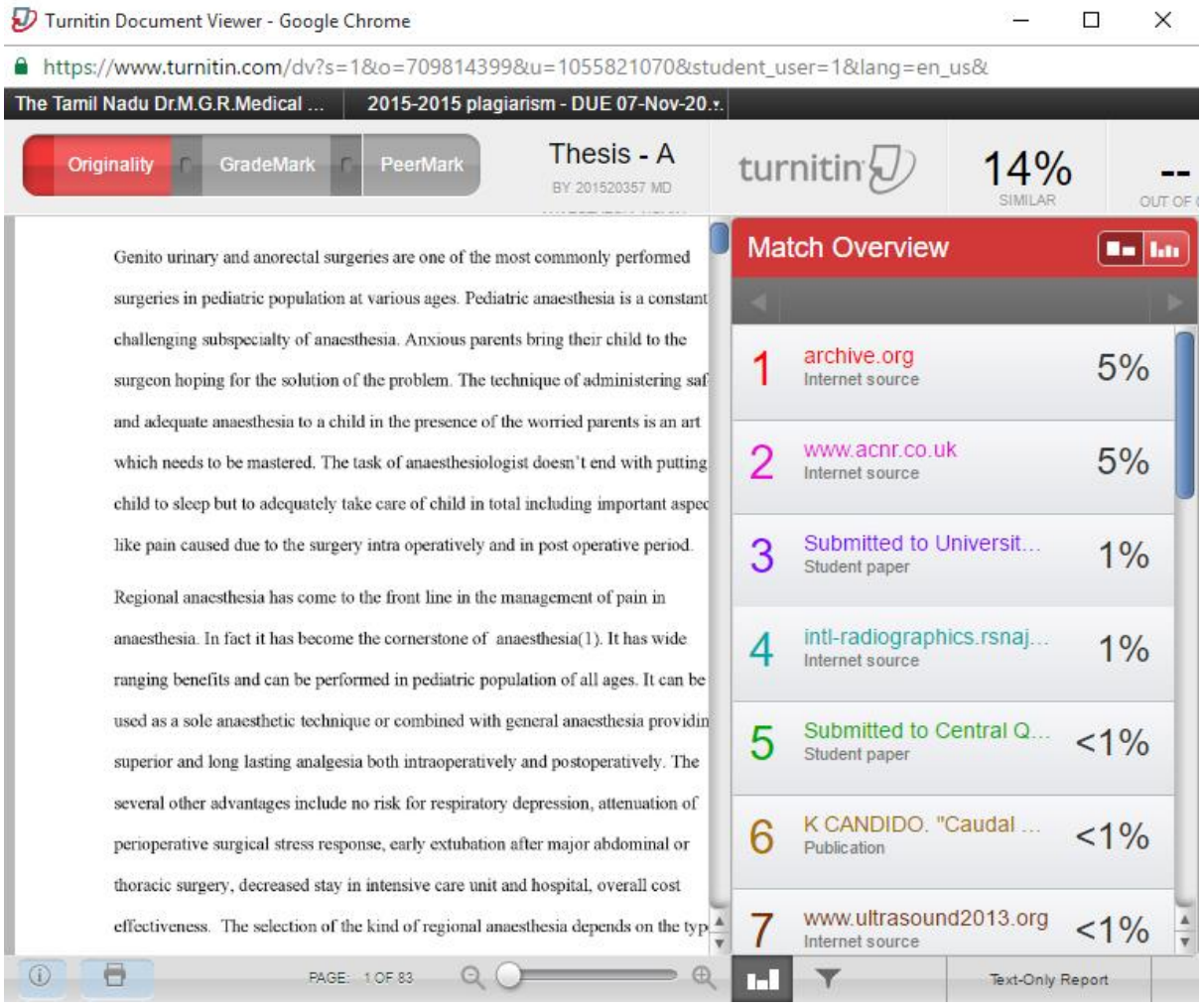


Introduction

Genito urinary and anorectal surgeries are one of the most commonly performed surgeries in pediatric population at various ages. Pediatric anaesthesia is a constantly challenging subspecialty of anaesthesia. Anxious parents bring their child to the surgeon hoping for the solution of the problem. The technique of administering safe and adequate anaesthesia to a child in the presence of the worried parents is an art which needs to be mastered. The task of anaesthesiologist doesn't end with putting the child to sleep but to adequately take care of child in total including important aspects like pain caused due to the surgery intra operatively and in post operative period.

Regional anaesthesia has come to the front line in the management of pain in anaesthesia. In fact it has become the cornerstone of anaesthesia(1). It has wide ranging benefits and can be performed in pediatric population of all ages. It can be used as a sole anaesthetic technique or combined with general anaesthesia providing superior and long lasting analgesia both intraoperatively and postoperatively. The several other advantages include no risk for respiratory depression, attenuation of perioperative surgical stress response, early extubation after major abdominal or thoracic surgery, decreased stay in intensive care unit and hospital, overall cost effectiveness. The selection of the kind of regional anaesthesia depends on the type of surgery and the duration. There is a comprehensive group of options in regional anaesthesia for providing good relief.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Acknowledgement

I acknowledge my dependence and gratitude to GOD Almighty in the successful completion of my dissertation.

I acknowledge my sincere and heartfelt gratitude to Dr. Ekta Rai, Professor, Department of Anaesthesiology, Christian Medical College, Vellore for her tireless efforts and guidance during the study.

I acknowledge my sincere thanks to Dr Jyothi Panwar, Assistant Professor and Dr Mugil, Senior Resident, Department of Radiology, Christian Medical College, Vellore for their expert advice on ultrasound imaging of Paediatric spine.

I acknowledge my sincere gratitude to Dr Justin James, Assistant Professor, Department of Anaesthesia for timely support and guidance during the study period.

I acknowledge my sincere gratitude to the Dr Sampath Karl Professor and Head, Department of Paediatric Surgery, Christian Medical College, Vellore for being generous in allowing me to recruit patients for the study.

I express my sincere thanks to Dr Antonisamy, Professor and HOD of Biostatistics, and Mrs Gowri Mahasampath of Biostatistics, Department of Biostatistics, Christian Medical College, Vellore for their valuable help in the study design and statistical analysis of this study.

I acknowledge my heartfelt gratitude to Dr Sajan Philip George, Professor and Head, Department of Anaesthesiology, Christian Medical College, Vellore for his support and encouragement throughout the study.

I specially thank the Anaesthesia technician team comprising Vignesh, Michael, Edward and Sam for their sincere and overwhelming support during the study.

Lastly, I thank all the patients who consented to be part of this study without whom it would have been impossible to have all this done.

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INTRODUCTION

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Genitourinary and anorectal surgeries are one of the most commonly performed surgeries in pediatric population at various ages. Pediatric anaesthesia is a constantly challenging subspecialty of anaesthesia. Anxious parents bring their child to the surgeon hoping for the solution of the problem. The technique of administering safe and adequate anaesthesia to a child in the presence of the worried parents is an art which needs to be mastered. The task of anaesthesiologist doesn't end with putting the child to sleep but to adequately take care of child in total including important aspects like pain caused due to the surgery intra operatively and in post operative period.

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The ultrasound has captured an important place in the armamentarium of the anaesthesiologist. It was Kapral who introduced ultrasound in anaesthesia practice in

1994(1) and later in pediatric anaesthesia by Marhoefer. Ultrasound has now become an important adjunct in regional anaesthesia. Its use has reduced the rate of complications as anatomy and entire length of needle is visualised clearly. In addition the success rates have improved tremendously nearing 100%(2). The need for volume of drug for regional anaesthesia performed with ultrasound compared with landmark technique has come down significantly(3). It has now become the standard of care in anaesthesia. Among the various regional blocks performed in children, caudal epidural block is the most commonly performed. The ease of identifying the surface anatomy and performing the block accurately with ultrasound is the main reason for the increasing use among anaesthesiologists. Ultrasound contributes to its increased safety and success rates(3). The use of ultrasound as a confirmatory test after caudal block has emerged superior to other techniques(4). Pediatric anaesthesia literature describe the anatomical relation of the posterior superior iliac spines and the sacral cornua as an equilateral triangle while some describe as an isosceles triangle(5). Robert et al described the surface anatomy relationship of the posterior superior iliac spines and sacral cornua as an equilateral triangle (6). Most often the caudal block is performed by appreciating the surface landmarks and the feel of entry of the needle into the caudal epidural space, but the route traversed by the needle is blind. Sometimes there can be some abnormal skin markers commonly a dimple seen on the sacral region. The general consensus is that to avoid caudal epidural block to avoid inadvertent dural puncture.(7) The presence of a skin marker may signal the unseen manifestation of abnormal anatomy of the spinal cord or meninges if associated with other system involvements(8). This clinical condition is called Occult spinal dysraphism, which is defined as

incomplete or absent fusion of midline neural, mesenchymal, and cutaneous structures, with or without herniation of underlying normal or abnormal neural tissue(9). This abnormality can be associated with anomalies of urogenital and anorectal structures arising from the mesoderm, for which commonly patients undergo surgery.

In a retrospective study done in South Korea Koo et al concluded that there is a prevalence of 7% of occult spinal dyraphism in children aged less than 2 years with urogenital anomalies which corresponds to 23 per 1000 compared to 7 per 1000 in general population(10). Meng-Fai Kuo et al conducted a study on 12 patients having VACTERL association. Out of the 12 children 7 patients had urogenital anomaly. Five children had tethered spinal cord (86%). They concluded that spine imaging is important to rule out tethered cord which can be corrected surgically(8). There is no published Indian study on assessment of caudal anatomy using ultrasound in a perioperative setting to detect occult spinal dyraphism. Galente et al strongly recommends of using ultrasound in patients with difficult caudal anatomy and to rule out anomalies in their retrospective analysis(11).

This study is an attempt to study the prevalence of occult spinal dysraphism detected in patients planned for urogenital and anorectal surgeries under the age of 2 years, and to study the relationship between the key landmarks of the sacral anatomy important for caudal epidural block.

AIMS AND OBJECTIVES

AIMS

To assess and describe sonological anatomy relevant to caudal epidural block, its correlation with surface anatomy, and its use to diagnose occult spinal dysraphism in children under 2 years of age coming for urogenital or anorectal surgery.

OBJECTIVES

1. To estimate the prevalence of occult spinal dysraphism using ultrasound in children aged less than 2 years requiring urogenital and anorectal surgeries.
2. To evaluate the relation between the posterior superior iliac spines and the sacral hiatus in caudal anatomy by ultrasound.
3. Correlation between location of sacral hiatus by landmark based technique and ultrasound.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Anatomy of the Sacrum

The sacrum is a large trilateral bone formed by fusion of five vertebrae (9). It is wedged between the two hip bones, forming the posterior and superior wall of the pelvic cavity. It has a blunted caudal apex articulating with the coccyx. The superior wide base articulates with the fifth lumbar vertebrae at the lumbosacral angle. It lies obliquely and curved longitudinally. The dorsal surface is convex while the pelvic surface is concave. The pelvic capacity is increased by the curvature. The sacral canal is located on the dorsal aspect of the bone. In children the individual sacral vertebrae are connected by cartilage. The sacrum comprises of trabecular bone covered by a shell of compact bone.(12)

Base

The upper surface of the first sacral vertebrae forms the base. It has a large body which is wider transversely and has a projecting anterior edge called the promontory. The vertebral foramina are triangular and the pedicles are short and diverge posterolaterally. The oblique laminae incline down posteromedially to meet at the spinous tubercle. The superior articular processed project cranially, having concave articular facets directed posteromedially to articulate with the inferior articular processes of the fifth lumbar vertebrae. The transverse process appears modified as a broad, sloping mass projecting laterally from the body, pedicle and superior articular processes. It is formed by the fusion of the transverse process and the costal element to each other and rest of the

vertebrae. The transverse process forms the upper surface of the sacral lateral mass, also called as the ala. The anterior and posterior longitudinal ligaments are attached to the ventral and dorsal surfaces of the first sacral body. The lowest pair of ligamentum flava are attached to the upper laminar borders. The lateral mass or ala is smooth superiorly, concave medially, and rough laterally. The smooth superior surface is grooved by the lumbosacral nerve trunk. The ala is covered by the psoas major muscle. The lower band of the iliolumbar ligament attaches to the rough surface, lying lateral to the fifth lumbar spinal nerve and to the anterior sacroiliac ligament.

Pelvic Surface

The pelvic surface is vertically and transversely concave. There are four pairs of pelvic sacral foramina communicating with the sacral canal through the intervertebral foramina, transmitting ventral rami of the upper sacral nerves. The area between the right and left foramina formed by the flat pelvic aspect of the sacral bodies bear evidence of their fused transverse ridges. The longitudinal bars between the foramina are the costal elements, which are fused to the vertebrae. The costal elements unite laterally and posteriorly fuse with the transverse process to form the lateral surface of the sacrum called as the ala. The ventral surfaces of the first, second and a small surface of the third sacral bodies are covered by the parietal peritoneum. The sigmoid mesocolon is also attached to the pelvic surface of the sacrum. The rectum lies in contact with pelvic surfaces of the third to fifth sacral vertebrae. The superior rectal artery bifurcates between the third sacral vertebrae and the rectum. The first three sacral ventral rami emerge from the pelvis sacral foramina and traverse anterior the piriformis.

The sympathetic trunk descends medial to the foramina, in contact with the bone and in a similar way the median sacral vessels descend in the midline. The lateral sacral vessels descend lateral to the foramina in close relation to the bone.

Dorsal surface

The median sacral crest lies on the posterosuperior aspect of the dorsal surface of the sacrum. It has four (sometimes three) spinous tubercles representing the fused sacral spines. The arched sacral hiatus is situated below the fourth sometimes the third tubercle in the posterior wall of the sacral canal. The hiatus is formed as a result of failure of the laminae of the fifth sacral vertebra to fuse in the median plane, leading to exposure of the posterior surface of the fifth vertebral body. There are four pairs of dorsal sacral foramina lateral to the median crest.(13) These foramina lead into the sacral canal through the intervertebral foramina. They transmit the dorsal ramus of a sacral spinal nerve. Three articular processes located on the inferior aspect of the fifth sacral vertebrae are free, project downwards at the sides of the sacral hiatus as sacral cornua. They are linked with the coccygeal cornua with inter cornual ligaments. The lateral sacral crest found lateral to the dorsal sacral foramina is formed by the fusion of transverse processes.

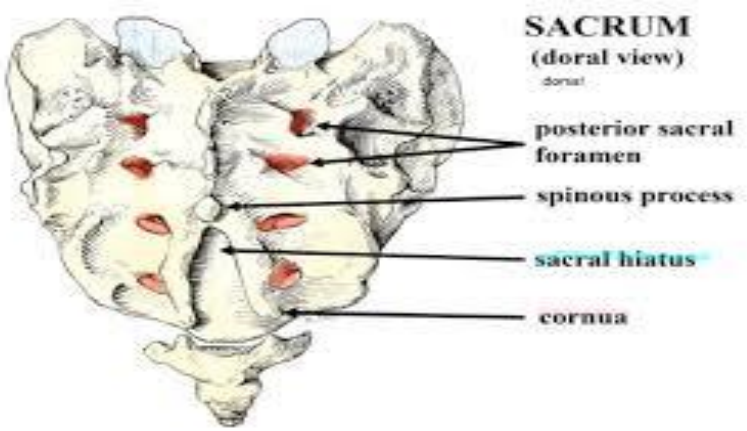


Figure 1: showing dorsal surface of sacrum.

Lateral surface

The lateral surface is formed by fusion of the transverse processes and costal elements. It is wide above and narrows in its lower part. The broad upper part has an auricular surface for articulation with the ilium. The posterior part of the auricular surface is is rough due to attachments of spinal ligaments. The auricular surface is covered by hyaline cartilage, formed by the costal elements. The surface appears more rugged with advancement of age. The area behind the auricular surface has few depressions for attachment of strong interosseous sacroiliac ligaments. The sacrospinous and sacrotuberous ligaments are attached below the auricular surface between the coccygeus anteriorly and gluteus maximus posteriorly

Apex

The inferior surface of the fifth vertebral body forms the apex of the sacral bone. It has an oval facet for articulation with the coccyx.

Sacral Canal

This canal is formed by the sacral vertebral foramina as a continuation of the vertebral canal and is triangular in cross section superiorly(12). It is a prismatic cavity extending through the length of the bone, following its curves and is continuous with the lumbar vertebral canal. The anterior wall of the canal is formed by fusion of bodies of the sacral vertebrae and the posterior wall by fusion of laminae. The lateral wall has four intervertebral foramina, through which the canal is continuous with the sacral and dorsal sacral foramina in the lateral aspect. The opening at the caudal end is called the sacral hiatus and is covered by the sacrococcygeal membrane. The anterior sacrococcygeal ligament consists of few fibres passing between the anterior aspects of sacrum and coccyx. The lateral sacrococcygeal ligament are present on either side connecting the inferior lateral angle of the sacrum to the coccyx. It covers the fifth sacral nerve exiting between the sacral cornua and the coccyx.(13) The extradural space in the canal can be compartmentalised due to fibrous strands in the canal. This may be the reason of failure of caudal extradural block in providing uniform anaesthesia(12).

The contents of the canal include:

1)Dural sac ending at the lower border of the second sacral vertebra usually.

2)Pia mater continuing as the filum terminale.

3)Venous plexus formed by the lower end of internal vertebral plexus. The vessels in the plexus are found more anteriorly than posteriorly.

4)Areolar fatty tissue which are found to be more dense in males than in females.

5) Cauda equina, filum terminale and the spinal meninges. The subarachanoid and subdural spaces end approximately at the level of the middle of the sacrum. The filum terminale with its meningeal coverings emerge below the sacral hiatus and pass beyond the sacrococcygeal ligament to attach to the coccyx. The fifth sacral spinal nerve root also exits through the sacral hiatus.

Applied Surface Anatomy

Various authors in anaesthesia literature have difference in opinion on the surface anatomical relation of the posterior iliac spines and the cornua of the sacrum. Many of the authors conclude that the three anatomical points have an equilateral triangle while newer opinion consider it to be an isosceles or a scalene triangle(14,15). This relationship has been use to locate the sacral hiatus before performing the block. Kim et al conclude from their study that assumption of the triangular relation being an equilateral or isosceles, was a myth and cannot be applied in locating the sacral hiatus for Korean population. This was validated in their study using an ultrasound(16). In some patients, identification of the sacral hiatus by palpation can be difficult because of anatomical variations or obesity. Veyckeman et al reported from their study conducted in 1100 paediatric patients that there was a difficulty in identifying the sacral hiatus in 11.2% of the patient (17).

Embryology

The process by which spinal dysraphism occurs is well understood if the embryology of the normal spinal cord is appreciated(18). The development takes place in three stages. The three stages are named as gastrulation, primary neurulation and secondary neurulation(19). Abnormalities can happen at any stage leading to dysraphism. Open spinal dyraphism occurs as a result of problems occurring during the earlier stage called primary neurulation. Closed spinal dysraphism occurs due to problems arising during the last stage of development called as secondary neurulation.

The time period of organogenesis starts from the third to eighth weeks of gestation. During the gastrulation phase there is an initial trilaminar plate containing all three germ cell layers namely the ectoderm, endoderm and mesoderm. The further development of all the tissue arise from these various layers. By the third week of development, the ectodermal layer gets the shape of a disc which is broad in the cephalic region and narrow at the caudal end. The overlying ectoderm gets thickened to form the neural plate. The cells of the plate form the neuroectoderm. Ectoderm will give rise to the central nervous system and skin, endoderm to the viscera, and mesoderm to the musculo-skeletal system. In this stage the midline notochord develops from the, midline primitive streak. This stage lasts for 16-18 days of intrauterine period.

The next stage called primary neurulation, which results in the development of brain and spinal cord (20). It is the process by which the neural plate forms the neural tube. This occurs during days 18-28 of intrauterine period. This phase involves the development of two ectodermal folds arising from the lateral edges of the neural plate.

The region in the middle forms the neural groove. The neural folds approach each other slowly in midline and starts fusing initially in the cervical region, proceeding cranially and caudally. With this the neural tube is formed. The neural tube can communicate with the amniotic cavity through the anterior and posterior neuropores before fusion. later the folds fuse at the anterior and posterior neuropores. In the midline, fusion occurs forming the brain characterised as brain vesicles (rostral end) and narrow tubular structure as spinal cord (caudal end). Thus the primitive nervous system is formed by ectodermal fusion. After this physical separation from the ectoderm happens which is called nondisjunction, wherein the remaining ectoderm goes on to become the skin. After completion of nondisjunction the process of secondary neurulation or development of spinal cord begins.

The secondary neurulation occurs during 28-48 days of intrauterine period. A separate pool of pluripotent stem cells located at the tail end of the embryo is called as caudal cell mass. This mass gives rise to the conus, cauda equine, parts of the genitourinary tract and the hindgut. The neural structures which arise from the caudal mass join the distal part of the spinal cord formed previously by primary neurulation. By about eight weeks of gestation, the spinal neural tissue lengthens down to the caudal end of the spinal column. In the next stage the spinal cord ascends rostrally so that the conus assumes its position in the lumbar region. Between eight and eighteenth week of gestation the bony vertebral column grows disproportionately faster than the neural elements. As a result the spinal cord ends up high in the vertebral column. This is called as caudal ascent or migration of the cord. By 25 weeks of gestation the development is complete. By around two months of age the position of the lower end conus medullaris

should be roughly at L1 or L2 vertebrae. The normal ascension of spinal cord is complete by 3 months. The process of ascension can be arrested in the presence of spinal dysraphism. The failure of secondary neural tube closure and incomplete nondisjunction are the pathologies of occult spinal dysraphism.

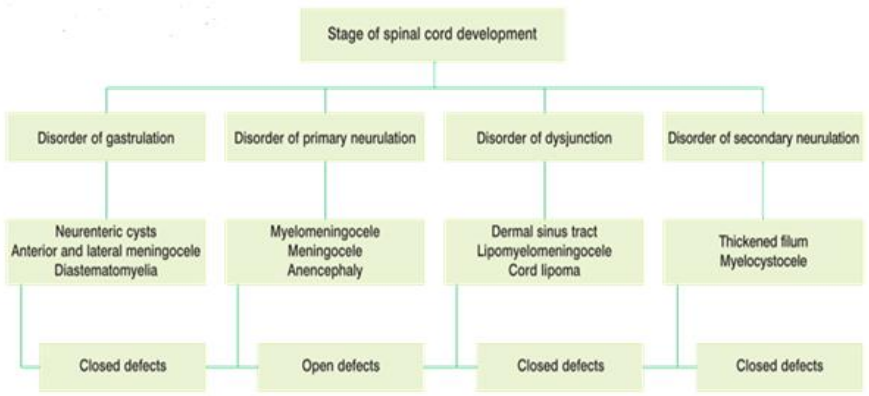


Figure 2 : showing stages of Spinal Cord development.

Ossification

The sacrum resembles a typical vertebrae in the way ossification of its segments take place (12). The primary centre for the centrum and each half of the vertebral arch appear between the ten and twenty weeks. The primary centres of the costal elements of the upper three segments appear superiorly and laterally to the pelvic sacral foramina. Each costal element unites with the corresponding half vertebral arch between second and fifth years of life. The newly formed conjoined element fuses anteriorly with the

centrum and posteriorly with the opposite element by about the eighth year. The upper and lower surfaces of each sacral body are covered by an epiphyseal plate of hyaline cartilage. In the lateral aspect successive combined vertebral arches and the costal elements are separated by hyaline cartilage. The epiphyseal centres for the costal elements appear at the lateral aspect of the hyaline cartilages. They lie between adjacent costal elements. There are two anterior and posterior centres which lie between the first, second and third vertebrae. The ossification thereon spreads from these centres to auricular plates. The sacral bodies unite later at their adjacent margins by about twenty years of age.

Variants

There can be many variations with the sacral bone. It may contain 6 vertebrae. This occurs due to development of an additional sacral element or by incorporation of the fifth lumbar vertebrae or the first coccygeal vertebrae. The inclusion of the fifth lumbar vertebrae is called as sacralisation. This is usually incomplete and limited to one side. Other abnormalities include a large fifth lumbar transverse process articulating with the sacrum at a posterolateral angle with the base. Reduction of sacral constituents can occur by lumbarisation of the first sacral vertebrae.

Abnormalities of the sacral canal are not uncommon and they include:

1) Displacement of hiatus in the upward or downward direction.
2) Complete or partial narrowing of the sacral canal. This makes needle insertion difficult.

3) Ossification of the sacrococcygeal membrane.
4) Failure of lamina to fuse leads to absence of the posterior wall of the sacral canal.
5) Extension of dura to the level of third sacral vertebra.
6) The hiatus can be seen in different shapes. They range from being long and narrow to short and broad.
7) The extradural space below the hiatus can be deep or excessively shallow.

Sonoanatomy of Paediatric Spine

The development of real-time ultrasound and high frequency array technology has revolutionised the approach of regional anaesthesia.(15) The clearer and detailed information about spinal anatomy and pathology has made this modality of investigation tremendously useful. However, it has its own limitation of use in the neuraxial region in older children because of ossified posterior bony arches. Whereas in the infants these structures are incompletely ossified and being cartilaginous, they provide a good acoustic window of the spinal cord. The spinal cord can be imaged in the sagittal(longitudinal) and axial (transverse plane). Ossification of paediatric spine starts by end of first year and ends by completion of 2 years of age. The quality of information from images can be unrivalled when performed with attention to detail.

Indications for Paediatric Spine Ultrasound(21):

1) Presence of lumbosacral cutaneous markers like
    a) Skin dimple
    b) Paramedian deep skin dimple

c) Deviated gluteal cleft

d) Tufts of hair

e) Hemangiomas

f) Skin tags

g) Midline masses like lipoma

h) Discolourations of skin

2) Patients diagnosed with caudal regression syndrome, sacral agenesis
3) Babies born with ano-rectal malformations like imperforate anus or anal stenosis
4) Evaluation of suspected defects like tethered cord, syringomyelia, hydromyelia, diastematomyelia etc
5) Followup of sequlae due to injury

a) hematoma post spinal tap

b) posttraumatic cerebro spinal fluid (CSF) leakage

c) sequelae of previous instrumentation, infection or haemorrhage

6) Post op assessment of cord untethering surgery.
7) To guide for difficult lumbar or epidural puncture.(21)

Contraindications:

1) Pre operative evaluation for open spinal dysraphism.
2) Examination of the contents in a closed neural defect covered by a thin skin.

Equipment

Ultrasound scan of infant spine is to be done preferably in real time using high quality and high frequency linear array transducers of frequency typically between 7.5-12MHz(22). Curvilinear or sector transducer is used for scanning the craniocervical region, while linear array transducers are preferred for scanning the remaining spine. Panoramic views of the vertebral canal if possible are helpful in getting overall view of the entire spinal cord and thecal sac. Machines with split-screen facility enables contiguous sagittal images of the spine displayed along with image of the longer length of the spine. This enables to determine anatomical landmarks and counting vertebral levels.

Technique of examination

The ultrasound scan can be performed in various positions like placing the infant in prone position or by making the baby lie on his or her side with knees flexed. The flexed posture maximises the acoustic window in axial views. For infants under anaesthesia it is best to place them in lateral position with special attention to airway. Flexion of knees on to abdominal wall until adequate spacing of the spinous processes and visualisation is adequate. The scan should be performed in a warm room or covered adequately, as infants may lose temperature due to exposure. Use of warmed ultrasound gel will be comfortable for the baby. Plenty of gel should be readily made available throughout the procedure. For an outpatient scan, infants can be recently fed or a pacifier dipped in sweet syrup placed in the mouth and placed comfortably. The assessment of the cord

should be done in sagittal and longitudinal planes. The examination can be focussed to the lumbosacral region and the lower thoracic region. In selected cases entire craniocaudal region screening can be done if acoustic window is good.

In the assessment for a suspected tethered cord, the level of termination of conus is very important. The salient points to be noted during scan are the cord position in the spinal canal and cord pulsations. The positional related abnormality in tethered cord is dorsal apposition of the cord within in the canal. The cord and the roots move in rhythm of the cardiac pulsations of the spinal CSF. When the patient is positioned laterally, the nerve roots lie in the dependent position and pulsate freely with cardio-respiratory motion. Documentation of the motion of cord and roots can be best done using M-mode of the ultrasound. The spinal cord shows dorsoventral movement with changes in position and while crying. Video recording of motion of the cord and roots for documentation is good for reproducibility. The other important feature in relation to tethered cord is to measure the thickness of the filum terminale and its appearance. Normal thickness of filum terminale is 2mm. Any measurements more than this needs to be documented.

The integrity of the cord has to be assessed in detail. There can be pockets of abnormal fluid collection such as hydromelia, arachanoid cysts, anterior or posterior meningocoeles or pseudomeningoceles. They need to be identified with their corresponding vertebrae levels. Conditions like diastematomyelia are best identified in the transverse imaging and off-center scanning. The subarachanoid space appears as a clear anechoic appearance interrupted at regular intervals by normal hyperechoic nerve roots and ligaments. The spaces between the meninges need to be assessed to rule out masses, lipoma and hematoma. The dura or thecal sac usually ends at the level of S2

vertebrae and has to be documented. The nerve roots usually lie separated within the dural sac.

Patients can be positioned in upright position to describe meningocoeles or pseudomeningocoeles. Another advantage of this position is for patients with failed lumbar tap. When the child is seated and leaning forwards, CSF accumulates in the thecal sac due to gravity dependent collection. This enables for a successful CSF tap.

For completion the vertebral bodies and the posterior elements must be assessed for any possible deformities. Transverse views are best in visualising dyraphic defects with exposed posterior elements.

Approaches for Ultrasound scan

The normal Sonoanatomy of the spinal structures can be viewed best with reference to the planes used in imaging(15). There are three common approaches

a) Transverse approach
b) Sagittal approach
c) Parasagittal approach

Normal Sonoanatomy

Extraspinal Sonoanatomy

The skin surface appears as a narrow echogenic bilaminar strip and the subcutaneous fat lying below forms an intermediate to low echogenicity plane. The lumbosacral fascia lying further beneath which is strongly echogenic, blends with hypoechoic interspinous

ligaments and paraspinal musculature. Deep to the coccyx gas with in the rectum can be seen as an echogenic structure.

Spinal Sononatomy

The spinal column is composed of 33 individual segments, which are unfused in the cervical (7 segments), thoracic (12 segments) and lumbar (5 segments) region. The partially fused segments are the sacral (5 segments) and coccygeal (4 segments). The paired echogenic ossification centres are present in all vertebral bodies form the posterior neural arches(21). These fuse in the midline only by the end of first year of life. In the sagittal plane the echogenic vertebral body complexes lie deep to the anechoic CSF filled thecal sac. The posterior neural arches lie superficial to the thecal sac, varying with level of spine cast echogenic shadowing within the canal. With increase in age they become more echogenic and forms barrier to insonation of underlying structures. In early neonatal period the coccyx appears hypoechoic extending caudal to the sacral vertebrae.

To begin with general cord morphology should be assessed. The vertebral levels need to be identified and counted properly so that the level at which various structures end can be documented. The vertebral levels can be numbered in the following ways. The echogenic, rectangular ossified sacral bodies appear as a curved stretch in the sagittal plane.

1) Follow the normal curvature of the lumbar vertebrae to trace the last or fifth lumbar vertebrae, and then start counting cephalad. This technique is more reliable and reproducible.
2) The last thoracic vertebra attached to a rib can be presumed to be T12 and then lumbar vertebra can be numbered below.
3) When the level of conus cannot be assessed as normal or abnormal, it would be helpful to do it with an x-ray. The skin friendly radio-opaque marker can be marked on the skin under ultrasound guidance, followed by a spine radiograph.
4) The coccyx bone if ossified has a round shape compared to the rectangular lumbar vertebrae. So numbering from below upwards from coccyx is also helpful in determining levels.

The lumbar vertebrae has a cleft in the middle of the body, which contains the basivertebral veins. The discs intervening between the bodies appear hypoechoic reflecting the nucleus pulposus which has a gel-like texture. The size of nucleus pulposus seen decreases in size with age.

Once the numbering of the vertebra has been completed, the level of the termination of conus has to be determined. Normally the conus ends at a level ranging from lower border of L1 to L3 intervertebral disc. In preterm neonate the conus can extend up to upper border of L3 vertebra. In foetuses and extremely preterm neonates the level of conus can extend up to lower end of L3 vertebra. The levels at which the conus ends need to be documented and follow-up scans may be needed to establish a low lying conus.

Sonoanatomy of Sacral and coccygeal region

The epidural fat appears echogenic and fills the sacral canal. It blends with the dura which is filled with the anechoic cerebrospinal fluid(CSF).

Sonoanatomy of Lumbar region

On sagittal scanning, the vertebral bodies appear echogenic forming the deep length of the spina canal. They are separated from the echogenic anterior dural sac by a thin band of echogenic fat in the anterior epidural space. The echogenic posterior dural sac wall lie deep to the posterior neural arches. The dural sac contains the linear echogenic nerve roots of the cauda equine bathed in the CSF. The cauda equine appears more symmetrical progressively, lying on either sides of the midline in the upper part. In the axial plane the cauda equina appears as an amorphous mass of echogenic structures filling almost all of the dural sac in the lower part. The filum terminale which is a single strand of neuroglial tissue extends from the tip of the conus, piercing the dural sac and finally attaching to the posterior aspect of the coccyx. On ultrasound in the sagittal plane it is identified as a linear midline echogenic structure lying posterior or within the cauda equina. No nerve roots are seen arising from the filum terminale.

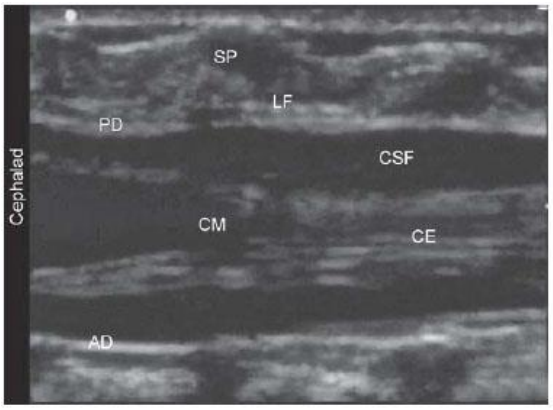


Figure 3: ultrasound image showing lumbar Sonoanatomy. CM-Conus medullaris, CE – Cauda equina, CSF – Cerebrospinal fluid, PD - Posterior dura, AD – Anterior dura, SP – spine

Sonoanatomy of Thoracic region and Conus Medullaris

The termination of the spinal cord is called the conus medullaris. It can be located anywhere between T12 and l2. It is the last segment from which the nerve roots arise. The filum and the conus need to be differentiated clearly in planning of treatment of tethered cord. In the upper lumbar region, the hypoechoic cord is focally enlarged and then then funnels down as the conus. The conus is usually surrounded by symmetrical arrangement of the the cauda equine. It is identified in the sagittal plane as a conical structure. Sometimes the ultrasound provides a superior image clarity of the conus than the MRI. In the thoracic spinal canal, the cord lies approximately one third to halfway between the anterior and posterior margins. The central echo complex forms a single strongly echogenic line or lines within the spinal cord and a centrally located echogenic dot or ring. This complex represents the central canal of the spinal cord. There ca be a physiological enlargement of the central canal called as dilated ventricular terminalis.

This is continuous and splays the central echogenic complex. The spinal cord is visualised as hypoechoic structure lying freely with in the cerebrospinal fluid, seen best in the axial images of the middle and upper thoracic region. The spinal cord is suspended within the spinal canal by the dentate ligaments. They are attached to the equator of the cord and extend laterally to be attached to the dural sac. The paired ventral and dorsal roots can be seen arising from the spinal cord.

Sonoanatomy of Cervical region

A sector transducer is used to scan in the sagittal plane to image the craniocervical junction and the cervical spinal cord. The pons, medulla and cisterna magna can also be visualised. The pons and medulla appear hypoechoic, while the cisterna magna with the CSF appear as a triangular space posterior to the medulla and craniocervical junction. The white and grey matter of the spinal cord appear homogenously echogenic. The anatomy seen on the ultrasound is not superior to the MRI, but correlates with it. In fact the ultrasound can be better than the MRI in the earlier months of life in depicting delicate cord details. The added advantage of ultrasound over MRI is that anaesthesia is not needed.

Vascular structures

The spinal cord is supplied by the anterior and posterior spinal arteries. They are seen as a tubular midline structures on the ventral and dorsal surfaces of the spinal cord respectively. This can be confirmed with Doppler imaging. The vertebral venous plexus is located in the epidural fat surrounding the dural sac. They are anechoic structures

visualised in the sagittal and axial planes. The basivertebral venous plexus drain blood from the vertebral bodies in to venous plexus located within the spinal cord. They are seen lying within the cleft of the vertebral bodies situated posteriorly.

Spinal dysraphism

Spinal dysraphism is an umbrella term describing any of the anomalies involving the spinal cord, cauda equina or overlying tissues such as the vertebrae, muscles and skin (18). It is defined as incomplete or absent fusion of midline neural, mesenchymal, and cutaneous structures, with or without herniation of underlying normal or abnormal neural tissue This term denotes all forms of incomplete fusion or malformation of midline structures. It can involve cutaneous, osseous and neural elements alone or in combination. Thorough knowledge of the embryologic development of the spinal cord and the meninges, along with their variations are important prerequisites for diagnosis. The anomalies can be congenital or acquired.

. They can be classified further into two categories

1) Spina bifida aperta – it is the most severe form of midline fusion defect with protrusion of uncovered neural tissue surrounded by the meninges. Egs. meningocoele, meningimyelocoele.
2) Spina bifida occulta - this category include a heterogenous group of lesions having a tethered spinal cord with an intact skin cover. e.g. Spinal lipoma dorsal dermal sinus, tight filum terminale syndrome, diastematomyelia). The anomaly may or may not be associated with a cutaneous stigmata.

In summary it includes

1) Anomalies of all forms wherein there is incomplete fusion of neural tube, meninges, vertebral bony column and skin
2) Failure of separation of the germinal layers
3) Abnormal growth of ectopic cell nests
4) Disturbance in growth of an otherwise normal tissue

Classification of Spinal Dysraphism

Open spinal Defects	Myelomeningocoele
	Meningocoele
	Anencephaly
Closed Spinal defects	Thickened Filum Terminal
	Lipomyelomeningocoele
	Diastematomyelia
	Intraspinal Lipoma
	Dermal sinus tract
	Myelocystocoele
	Anterior meningocoeles

Epidemiology

The incidence of open spinal dysraphism is about 1-3 in 1000 live births while that of closed spinal dysraphism is unknown but is estimated to be higher than open, which is approximately 6 per 1000(18).The combined incidence of spinal dysraphism ranges between 0.5 and 2.5/100 live births in the general population. This varies between different regions and populations. The incidence of occult spinal dysraphism depends on how often relatively minor abnormalities are evaluated. Sometimes these conditions are detected incidentally. The prevalence of spinal dysraphism has decreased due to food fortification with folic acid during the antenatal period. With advancement in technology the detection rate of spinal dysraphism in utero has increased.

Multiple factors have been implicated in the etiology, both environmental and genetic. Environmental factors include poor socioeconomic status, folate deficiency, use of ante natal anti epileptics, maternal age more than 40 and less than 19 years (18). There has been no conclusion on ethnicity as a causative factor of spinal dysraphism. Numerous genes have been investigated but no specific gene has been identified as a genetic cause. Trisomy 13 and 18 have been linked with neural tube defects, while 10%of cases are attributed to chromosomal defects.

Occult Spinal Dysraphism

1) Anterior meningocoele

They are composed of dorsal herniation of dura, arachanoid filled with CSF protruding into the subcutaneous tissues of the lower back and are skin covered.it can be simple or complex. A simple meningocoele does not contain neural elements,

while a complex meningocoele is associated with anomalies of spinal cord and the bony vertebral column. The bony defect includes sacral dysgenesis. The meningocoeles can be symptomatic or asymptomatic. The symptoms include swelling, bowel or bladder dysfunction. Ultrasound imaging reveals anechoic fluid filled sac communicating with the spinal canal. The sac can be uniloculated or multiloculated. The cord can appear abnormal if it's a complex meningocoele. The size and shape of the sac can vary with position or Valsalva manoeuvre.

Lateral meningocoeles are another entity which are described as CSF filled protrusions of dura and arachanoid extending through the neural foramina. They are found mostly in children diagnosed with Ehler – Danlos syndrome, Marfan's syndrome or neurofibromatosis. They commonly present in older children and most often picked up on MRI.

2) Dorsal dermal sinuses

They result due to incomplete disjunction of the cutaneous ectoderm from the neuroectoderm.they are lined by epithelium and extend deeper into the skin for varying distances.thye can extend into the dural sac by penetrating it, and can end in the subarachanoid space, conus medullaris, filum terminale, a nerve root or as a echogenic dermoid cyst. They are seen anywhere from the skull to coccyx. The most common location is the lumbosacral region. Finding such sinuses in other regions like thoracic, cervical and occipital are rare. On finding such sinuses it is important to elicit history of any discharge or recurrent meningitis. So the important risks associated with dermal sinuses are infection and

compression by any other dural mass. On the ultrasound the sinus track appears as an echogenic tube with a hypoechoic centre. The direction of the track is oblique extending caudally to the spinal column by piercing the lumbar fascia and later in cephalad direction into the spinal canal. For detailed and definitive examination MRI is warranted.

3) Spinal lipomas

They are masses of fatty tissue covered by skin having connection with the leptomeninges or spinal cord(23). These occur as a result of premature disconnection of the neuro ectoderm from the cutaneous ectoderm. They can be divided onto four groups.

a) intradural lipomas

this lipoma is seen in a subpial position in a dorsal cleft of the open spinal cord.

b) lipomyelocoele

This is similar to the myelocoele wherein in addition to the exposed neural tissue, there is an overlying layer of lipoma which is continuous with the subcutaneous fat and intact skin.

b) Lipomyelomeningocele

About 50% of skin covered lumbosacral masses are constituted by lipomyelomeningocele. The clinical features are subcutaneous lumbosacral mass presenting to clinicians before 6 months of age or later in life with neurological symptoms. It appears asymmetrical leading to difference in length of nerve roots and is located posterior to the neural placode. The meningeal sac extend in to the

soft tissue and can extend into the spinal canal, causing the spinal lamina, paraspinal muscles and lumbosacral fascia to be separated in the midline. It is usually not associated with any Chiari Malformation(24).

c) Fibrolipomas of the filum terminale

it can be variant of normal spinal development. In this entity the filum terminal is expanded because of fatty tissue. The normal dimension of filum terminale measures about 2mm in diameter. This is seen on the ultrasound as a thickened echogenic filum terminale. The presence of abnormally low position of the conus medullaris and thickened filum terminale constitute an entity called tight filum syndrome.

4) Diastematomyelia

This malformation is characterised by partial or complete sagittal division of the cords into two hemichords, each having separate central canal, single ventral and single dorsal horn. Each hemichords have their own ventral and dorsal nerve roots. The anomaly arises as a result of sagittal splitting of the embryonic notochord, which results in hindrance to cell migration from Hensen's node. In about 50-75% of cases of diastematomyelia cutaneous stigmata is seen. The incidence is more in females than in males(9:1). The patient presents to the doctor at any age. The most common problem being orthopaedic like scoliosis, and othernon-specific neurological complaints. There are two types

Type 1 diastematomyelia- its incidence is about 40-50% of all diastematomyelia cases. This type is characterised by fibro-osseous bony spur between the two hemichords. The spur defines that each hemichord lies within its own dural tube. Vertebral anomalies include malsegmentation and is associated with scoliosis.

Type 2 Diastematomyelia. It has an incidence of 50-60% of all diastematomyelia cases. This is characterised by the presence of both hemichords lying within a single dural tube and is continuous with the normal thecal sac with no fibro-osseous spur interposed between. It is commonly located in the thoracolumbar region.

The diagnosis of diastematomyelia can be made during antenatal ultrasound. It is seen as a disorganised appearance of the vertebral column, with fusiform widening of vertebral segment and a visible dividing septum in the central widened area. It can be diagnosed with ultrasound in the neonatal period. Diagnosis can be delayed until the child develops some orthopaedic or scoliosis or neurological deficits.

5) Myelocystocoele

This type of malformation is characterised by dilatation of the central canal protruding dorsally through the bony spin bifida. They are seen anywhere from the cervical to sacral region. They are classically skin covered which makes them distinct from myelomeningocoele. The diagnosis can be established with help of ultrasound or MRI. It is classically seen as low lying conus ending in a cyst which has communication with the central canal of the spinal cord. The subarachanoid

space expands to surround the cord and terminal cyst. Terminal myelocystocoele can mimic the diagnosis of meningomyelocoele on inutero sonogram. The clue for differentiating myelomeningocole from myelocystocoele is that myelomeningocoele is almost always associated with Type 2 Chiari Malformation.

6) Split Notochord syndrome

It is a complex group of anomalies caused by an abnormal, persistent connection between the endoderm and ectoderm of the embryonic disc. This possibly occurs during gastrulation. These include dorsal enteric fistula, cyst, sinus and diverticulum. Dorsal enteric fistula is an abnormal connection extending from the intestinal cavity through the prevertebral tissues, vertebral body, spinal canal, spinal cord and posterior elements on to the skin surface posteriorly in the midline. The dorsal enteric cyst, sinus and diverticulum are seen along the course of the fistula as they can get obliterated anywhere in the path from the intestine to the skin surface. Neuroenteric cysts belong to the same enitity located anterior to the vertebral canal. Enteric cysts are seen within the spinal canal anterior to the spinal cord. Such lesions can be seen well on ultrasound.

Anomalies at risk for spinal dyraphism

a) Cloacal extrophy
b) Cloacal malformation
c) High imperforate anus
d) Ectopic or low imperforate anus

Tethered cord syndrome

Tethered cord is the clinical manifestation of the anatomical abnormalities that constitute spinal dysraphism. Patients with dysraphic anomalies have clinical features of neurological, urological, anorectal and orthopaedic pathology due to the tethered cord. The diagnosis of tethered cord is a challenge in clinical practice. The clinical features are varied in different age groups. It may be present at birth or asymptomatic initially but symptoms may progress with growth presenting during adolescent or early adulthood. The constellation of progressive development of sensorimotor neurological, sphincter, sexual dysfunction and orthopaedic problems follow a period of growth from childhood to early adulthood. Sometimes anomalous structures attached to the spinal cord present with signs and symptoms reflecting the local effect on spinal cord and not essentially due to tethering.

Causes

They include primary(congenital) and secondary or developmental(acquired)

Congenital anomalies, spina bifida in particular are particularly associated with congenital tethered cord syndrome. Spina bifida presents as a birth defect due to incomplete closure of the posterior spinal cord and bony vertebral lamina. The birth defects located at the caudal end of the spinal cord can present with symptoms of tethered cord.

Pathophysiology of tethered cord

The term “tethered cord refers to a low lying spinal cord or conus probably due to traction retained on it. Many hypotheses have been proposed for the pathophysiology

in various literature but exact cause has not been established. The vertebral column continues to grow while the nerve roots of the cauda equina are held to the lumbosacral area. So due to this, the cord cannot ascend according to the vertebral column resulting in stretching of nerve roots. This results in vascular compromise as a decrease in blood flow ending in decreased mitochondrial activity and metabolic imbalance on the background of structurally abnormal neural tissue. Mechanical tethering of the spinal cord caused by fibrous bands and fatty tissue were identified in histopathological and imaging studies.

Cutaneous manifestations of Tethered Spinal Cord Syndrome

There are many cutaneous stigmata associated with tethered cord. Skin signs are seen usually as single and rarely multiple. The frequent ones seen are

1) Abnormal dimples
2) Skin tags
3) Subcutaneous pad of fat
4) Hemangiomas
5) Nevus
6) Hairy patches
7) Dermal sinuses
8) Altered gluteal folds

Figure 4: showing different types of skin markers.

Dimples seen at the lower back of babies are picked up on routine check-up which can be normal. Pathological dimples have other specific findings. The presence of a normal dimple in infants is about 4% in the general population. These dimples are located at the tip of coccyx and is palpable through the dimple. The features of pathological dimple include discharging, midline and situated above the natal cleft. Deeper dimples need to be further evaluated for a dermal sinus tract. Dermal sinuses tracts vary in their locations. Most commonly seen at the midline lumbosacral region(90%), rarely at the thoracic and cervical regions. They are lined by epithelium lined passages between the skin and the underlying tissues and even may extend upto the intradural space. They occur due to failure in separation from cutaneous and neural ectoderms. If undetected can lead to accidental dural puncture and meningitis.

The presence of a skin tag in the midline or a tail in the coccyx region has a strong correlation with spinal dysraphism. A true tail composed of fatty tissue, vasculature, muscle, and nerve fibres is extremely rare. Prompt evaluation should be done to rule out underlying dysraphism.

The presence of a lipoma or a subcutaneous fat cushion is the most common marker indicating underlying spinal dysraphism. About 80-90% of spinal lipomas may have extra cutaneous lesion. The extend of the lipoma can vary from being limited to the dermis or extend into the intraspinal space through a vertebral defect or just localised within an intraspinal compartment. Lipomyelomeningocoele is an example where the lipoma is seen spanning from dermis to intraspinal space.

Unfortunately, not all occult spinal dystrophic states are associated with a cutaneous stigmata, and those without markers can present later in life when other clinical features have manifested.

Clinical manifestations of Tethered cord Syndrome

A comprehensive clinical history of the various systemic involvement and a family history of associated abnormalities, maternal drug use during pregnancy, and pre-conception folate consumption is to be taken(18).

The clinical features include neurological, urological, orthopedic manifestations

The neurological features include sensorimotor dysfunction presenting as a combination of upper motor neuron and lower motor neuron lesions or pure lower motor neuron lesion based on the site of lesion. Lesions at the level of the conus present as a combination of UMN and LMN symptoms while lesions below the conus present with pure LMN symptoms. Parents report with delay in walking or imbalance while walking or change in gait worsening with exertion, development of toe walking and regression of motor milestones. Other features include change in muscle tone, contractures, spasms

or muscle atrophy. Sensory symptoms include back pain or radicular pain seen with older children. Local examination of the back may or may not show cutaneous markers warranting further investigations.

Approximately 50-70% of patients with spinal dysraphism have Orthopedic symptoms and signs are usually progressive deformities. They may be asymptomatic to start and later affect the lower limbs and spine as the child begins to grow. Lower limb deformities include pes cavus, varus, valgus and equinus deformities, tight Achilles tendons, clubbing, toe clawing, hammertoe, talipes and leg length discrepancy. Spinal anomalies include scoliosis, sacral dysgenesis segmental spinal dysgenesis. The complications arising out of orthopaedic lesions are low bone density, respiratory dysfunction, immobility, poor quality of life, spasticity. Sometimes the orthopaedic problems are managed surgically without suspecting the underlying neurological problem. If a patient has combination of orthopaedic and anorectal malformation, an ultrasound of the spine followed by confirmation with MRI is important.

Urological manifestations of spinal dysraphism occur when the structure and function of the upper and lower urinary tract are affected. The common urological problems include neurogenic bladder with associated vesicuoureteric reflux, overflow, recurrent urinary tract infections, stones and changes in continence. Children are brought with complaints of failure to attain continence or new onset incontinence. The presentation can be subtle with incomplete voiding, urinary frequency, stress incontinence and nocturnal enuresis uncoordinated detrusor and sphincter activity, can lead to permanent renal damage via high bladder pressures and recurrent urinary tract infections (UTIs). It is pertinent to evaluate the sphincter function early to avoid these complications.

Other rare urological problems include cryptorchidism, renal agenesis, horseshoe kidney and less commonly cloacal and bladder extrophy.

Bowel involvement with bladder dysfunction is common with dyraphism. Low and high anorectal malformations can be associated with spinal dysraphism, usually not visible directly visible but with imaging. Children present with constipation or fecal incontinence. The presence of any of these signs and symptoms on clinical examination should prompt further evaluation into the possibility of spinal dysraphism as the etiology. Sometimes, urogenital, hindgut and dysraphic spinal pathologies can constitute one of the genetic syndromes, such as VACTERL (vertebral defects, anal atresia, cardiac defects, tracheo-esophageal fistula, renal anomalies, and limb abnormalities), OEIS (omphalocele, exstrophy of the cloaca, imperforate anus, and spinal defects) and Currarino's triad (anorectal malformation, a sacral bony defect and a presacral mass).

Diagnosis

The arrival at a diagnosis of an occult spinal dyraphism is a challenging one, as the spectrum of the differential diagnosis is quite wide. The key is detailed history which includes antenatal history, clinical examination and good neuro radiology(9). Clinical examination is focused on any cutaneous stigmata, correlated with neurological, orthopaedic, urological and anal sphincter tone integrity. Abnormalities in these clinical systems signals a tethered cord. It is important in diagnosing tethered cord early because the damage caused by tethering may be irreversible later.

Imaging

Neuro imaging is paramount in the diagnosis of tethered cord. With the advancement in technology, imaging has become easily accessible and noninvasive. The presence of cutaneous features along with clinical manifestations should prompt for screening of tethered cord. Xrays have become obsolete as it does not reveal any cord anatomy and puts the patient at risk of unnecessary radiation exposure but helpful in finding bony defects. Ultrasound has emerged useful screening tool for ruling out spinal dysraphism in neonates or infants with features suspicious of tethered cord. Ultrasound enables to locate the level of conus, thickness of filum terminal, real time data, and the presence of spinal cord pulsations. MRI is considered as gold standard in the investigation of occult spinal dysraphism. A whole craniospinal MRI is recommended in the background of dysraphism to rule out other anomalies like Chiari malformations, hydrocephalus or syringomyelia.

Management of tethered cord syndrome

The care of patients should be by a multi disciplinary team comprising of neurosurgeon, rehabilitation specialists, urologist, nurses(18). Patients diagnosed with this syndrome can be symptomatic or asymptomatic. Asymptomatic occult spinal dysraphism is managed conservatively by regular out patient check up with active monitoring of development of new neurological orthopaedic or bowel/bladder symptoms. Surgery is indicated in following situations like onset of new clinical deficit due to tethering or presence of lesions like dermal sinus tracts associated with meningitis. Patients with

radiological features of spinal dysraphism need to be referred for a surgical opinion. The case for a prophylactic surgery is debated in literature. The general consensus is not to operate on patients with an intact anatomy and clinically asymptomatic. But there is a small evidence that children operated earlier in the clinical course had a favourable outcome(25).

In patients planned for surgical intervention, the primary aim is to untether the cord and preserve the function. The secondary aim will be to repair the associated anomalies seen in the exposed surgical field. For example, the presence of lipomas, sinus tracts have to be dealt with as they can cause problems in future. The surgical approach tracks the abnormality from the skin, through possibly abnormal subcutaneous tissues, fascia, and into the spinal cord. The rest of the surgery focuses on the structural untethering of the attachments between the spinal cord and surrounding structures. Once the spinal cord is untethering is done, dural closure and closure of the overlying tissues is performed. The procedure is preferably performed in a latex free field to avoid sensitisation. Spinal cord untethering surgeries are usually performed under intraoperative neurophysiological motor tract evoked potential monitoring. This also allows nerve root stimulation of neurologically intact structures and differentiate between structures that are functional from those which are and not. The current complication rates are low in centres with excellent pediatric neurosurgical expertise. In complicated cases partial untethering may only be possible.

The care of patients with tethered cord on follow up and post operative untethered cord patients need continued care by the multi disciplinary team. Immediate post operative issues like wound infection, wound integrity need to be taken care of well. Treatment

with antibiotics will be needed with any CSF leak. Patients need to be on lifelong follow up with treating team because of the possibility of recurrence with complex lesions. The presence of varied degree of physical, psychological, emotional and impairments need immense support and contribution from parents, caregivers, occupational therapists and physiotherapists. The family with such patients will need family focused rehabilitation to deal with the stress and psychological issues in bringing up children so that they can independently learn to manage themselves.

Regional Anaesthetic Implications of Occult Spinal dysraphism

Regional anaesthesia is increasingly being combined with general anaesthesia for pediatric patients planned for corrective surgeries of genitourinary and anorectal malformations. This anaesthetic practise has now emerged as the standard of care. Regional anaesthesia has wide range of benefits and can be used in pediatric population of all ages. The availability of ultrasound in theatre improves the safety profile of the regional technique performed. It is important to know the embryological basis of the connection between occult spinal dysraphism and genitourinary anomalies(10). These anomalies can be detected on a simple screening ultrasound scan. It is not uncommon that the attending anaesthesiologist encounters with some cutaneous abnormality seen over the lumbosacral region prior to performing neuraxial block. The presence of this cutaneous marker puts the anaesthesiologist in a dilemma whether to proceed with planned regional anaesthetic technique. The presence of a cutaneous marker is a relative contraindication for a neuraxial block (25). Geraldo Pianetti et al conducted a study of 2010 patients, wherein 144 patients had cutaneous markers and only 8 patients in those with cutaneous markers had occult spinal dysraphism. The ultrasound screening helped the treating team to decide further imaging post op and further surgical management for the spinal dysraphism. They concluded that it is worthwhile to do a screening ultrasound scan as it is cheap, noninvasive and has no radiation hazards(26). Robinson et al from their study in 229 patients suggested that simple cutaneous markers like dimple were not sinister as a sole indicator of occult spinal dyraphism(27).Chern et al conducted a retrospective study of 973 children referred for lumbar ultrasound due to the presence of skin marker of occult spinal dysraphism. Only seven patients (0.007%) in the skin

marker group and ten patients (0.057%) in the group having congenital anomalies had occult spinal dyraphism. They concluded that presence of skin markers are not reliable and were not conclusive of occult spinal dysraphism.(28)The anaesthesiologist having ultrasound knowledge of the pediatric spine can be the first physician to detect the presence of these occult anomalies before proceeding with the planned central neuraxial block. Few studies have shown accidental detection of spinal anomalies using ultrasound prior to performing regional anaesthetic blockade. Kim et al in their study of 500 patients, four patients who were planned for hypospadias repair had abnormal spinal sonoanatomy indicating occult spinal dysraphiam, which was detected on ultrasound screening done prior to performing neuraxial block(29). The planned neuraxial blockade was not performed to avoid injury to the spinal structures. Jeonmin et al Anaesthesiologist, Yonsei College of Medicine, Seoul published a case report where in a child posted for urology procedure had a tethered cord on ultrasound scan done in theatre prior to performing the caudal block. The caudal block was not performed and the child underwent MRI which confirmed the diagnosis. The child underwent detethering surgery after one month(30). Meng-Fai Kuo et al conducted a study of 12 patients having VACTERL association for a period of 3 years. Three children were excluded from the study due to post operative complications. Seven children out of the 9 children, had occult spinal dyraphism. They underwent successful untethering surgeries later. They concluded that spine imaging is important to rule out tethered cord in patients with VACTERL association having urogenital and anorectal malformations (7).There are other case reports wherein central neuraxial blocks performed in patients having occult spinal dysraphism had resulted in catastrophic

neurological complication(31). The patients with suspicious anatomy seen on ultrasound performed in theatre by anaesthesiologists having sufficient experience in ultrasound, can undergo further confirmative imaging investigations like MRI to clinch the diagnosis. These patients need to be referred for neurosurgical opinion for surgical corrective surgery like untethering or close observation for development of neurological symptoms. Thus with increasing use and availability of ultrasound in theatre, it is important to perform a ultrasound screening scan prior to performing regional anaesthetic technique in pediatric patients with urogenital and anorectal anomalies.

MATERIAL AND METHODS

MATERIAL AND METHODS

The proposal for the study titled "A CROSS SECTIONAL STUDY TO ESTIMATE THE PREVALENCE OF OCCULT SPINAL DYSRAPHISM IN CHILDREN AGED BELOW 2 YEARS FOR UROGENITAL AND ANORECTAL SURGERIES USING ULTRASOUND IN OPERATING ROOM OF A TERTIARY CARE HOSPITAL was reviewed and approved by The Institutional Review Board and Ethics Committee (Ref : IRB Min No: 9760)of Christian Medical College, Vellore.

INCLUSION AND EXCLUSION CRITERIA

All children undergoing corrective urogenital and anorectal surgery done by the Department of Pediatric Surgery in Christian Medical College, Vellore were included in the study with the following inclusion and exclusion criteria.

Inclusion Criteria:

1) All children aged less than 2 years whose parents/guardian having consented, posted for urogenital and anorectal corrective surgeries.
2) ASA physical status classification I and II.

Exclusion Criteria:

1) Children whose parents/guardian refused consent.
2) ASA physical status of classification III, IV, and V.
3) Children with obvious spinal anomalies eg: Meningocoele, myelomeningocoele.

Consent:

The information sheet with all relevant information in easy to understand language translated into the language of the child's parent or guardian is provided sufficiently earlier to the surgery for them to deliberate and clarify. The principal investigator explained about the study with the parent/guardian of the child and clarified their queries on the night before the surgery. The parent / guardian is invited to be part of the study and the consent signature is obtained on the consent form.

Study Protocol

The patients whose parent/guardian consented and fulfilled the inclusion criteria was enrolled for the study. The patient underwent routine pre anaesthesia checkup and followed fasting orders and premedication as per routine departmental unit protocol. The plan for anaesthesia was decided based on the type and duration of the surgery. The child was induced with inhalational agent (sevoflurane) and pulse oximetry monitoring was initiated, followed by intravenous access was established. For children with intravenous access, intravenous induction agents like propofol or thiopentone sodium titrated for their weight was used. The following monitors were secured - three lead ECG and non-invasive blood pressure. Once airway was secured, EtCo2 and end tidal inhalational agent monitoring was initated. Subsequently, the child was positioned in the left lateral position in a coordinated manner. The child was adequately covered to prevent hypothermia. The child's lower back was examined carefully for the presence of any cutaneous stigmata and was documented. The important landmarks of the surface anatomy of the sacrum identified by palpation were the two posterior superior iliac spines and the sacral cornua. These points form a triangular relationship and were

marked using a skin friendly marker. The lines joining the posterior superior iliac spines formed the base of the triangle and the lines from the either posterior superior iliac spines to the sacral cornua as the apex formed the side of the triangle. The measurements were done with the help of a steel scale and the measurements of the triangle was noted.

The ultrasound evaluation of the lumbosacral structures was done by the primary investigator and guide having reasonable experience with ultrasound use in regional anaesthesia and for vascular access. The ultrasound machine used for the scan was GE venue 40. The probes used for the scan were the hockey stick and the transverse probe, having a frequency of 7 Hz. The first 20 scans were performed in the presence of sonologists and planning was made regarding position, probes and measurements. The subsequent scans were done independently by us followed by images checked by sonologists. The ultrasound evaluation commenced with identifying location of the sacral hiatus and its correlation with surface anatomy method was documented. The sacrococcygeal ligament was visualised on the screen and its depth from skin was documented. The sacral hiatus was also identified in the same image and its depth from the sacrococcygeal ligament was noted. Further imaging of the lumbosacral anatomy was done systematically. The spinal cord was visualised in the thoracic region and was followed down to its end point as the conus. This point was confirmed in transverse and longitudinal planes and marked on the skin. At this point, the distance between the posterior border of the conus and dura and distance between the posterior border of the conus and skin was noted. The point at which the spinal cord ends, was documented with reference to the vertebral level. The filum terminale was identified further below after the ending of the conus. The thickness of the filum was noted in both transverse

and longitudinal planes. The distance between the posterior border of the filum and the dura and distance between the posterior border of filum and skin was noted. The presence of spinal cord pulsations was documented. The dura was visualised separately and its depth form skin was noted. The dura was followed further down to the point it ended and was documented on the skin surface and its relation to the sacral or lumbar vertebrae. The counting of vertebrae was done with the help of the guide pointer on the ultrasound screen below upwards. The distance between the point marked on the skin where the dura ended and the sacral hiatus was documented.

The planned regional technique was performed in patients with normal anatomy. All scans were done prior to performing the block. The central neuraxial regional anaesthetic technique was deferred in those who had abnormal anatomy and other modes of analgesia or alternative regional block was performed. The images with abnormal anatomy was counter checked by doing repeat scan after the surgery with the help of the radiologist. All the ultrasound images were stored protected in a flash drive in separate folders for each patient. The abnormal findings were discussed with surgeons, parents of the patient and further treatment plans were made for follow up in neuro surgery department.

Study Design

Cross sectional Prospective study

Figure 5: Ultrasound Machine used for study.

Statistics used for Sample size calculation

P = 7 % (Prevalence of occult spinal dysraphism in children below 2 years from a previous study) - Ultrasonography reveals a high prevalence of lower spinal dysraphism inchildren with urogenital anomalies(10).

Q= 93%

Type I (α error) α = 0.05

Precision (d) = 4

Applying the formula: (Zα)2PQ/d2

N = (1.96)2 x7x93/ (4)4

N = 150

Statistical methods used for Analysis

Categorical variables were summarised using counts and percentages. Quantitative variables were summarised using mean and standard deviation or median and range. Chi square test was used to compare the proportions between categorical variables. One way analysis of variance test is used for the comparison between three groups. all the significance levels were kept for $p<0.05$. All the statistical analysis were done using stata/ic 13.1.

RESULTS

RESULTS

The data collected have been analysed under the following categories.

1) Description of baseline characteristics
2) Cutaneous marker data.
3) Surface anatomy data.
4) Ultrasound measurements.

In this study we assessed 161 patients for eligibility to be recruited for the study. Parents of 2 patients refused to give consent. Data was collected from 159 patients and were analysed.

DESCRIPTION OF BASELINE CHARACTERISTICS

Gender Distribution

Table 1: showing gender distribution in the study population. (n=159)

Gender	Frequency (%)
Male	134 (84.3)
Female	25(15.7)

The percentage of males were higher in all age groups which suggest the incidence of urogenital is more common in males whereas anorectal malformations were higher in the female population in our study group of 159 patients.

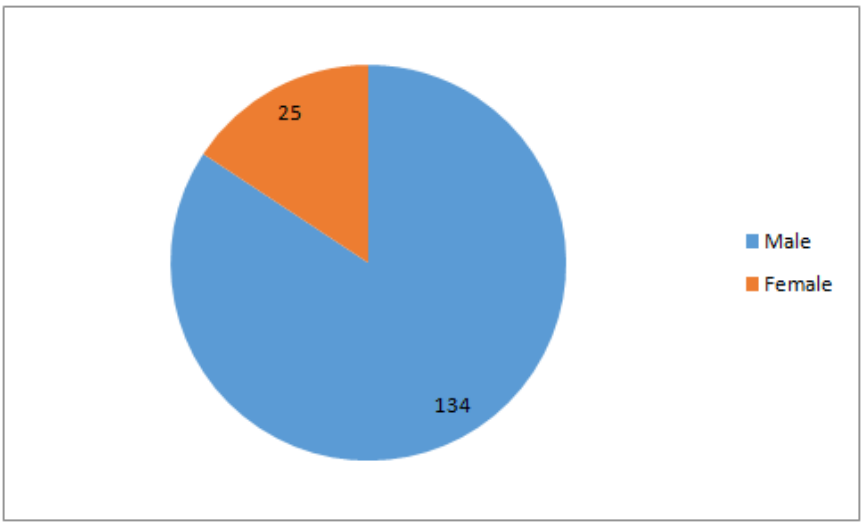


Figure 6 : showing gender distribution in study population.

Age distribution

Patient's age ranges from 1 month to 24 months (excluding 8 neonates). The mean age was 12.5 months and S.D = 7.39. the mean age of the neonates was 6.63 days and SD= 4.4

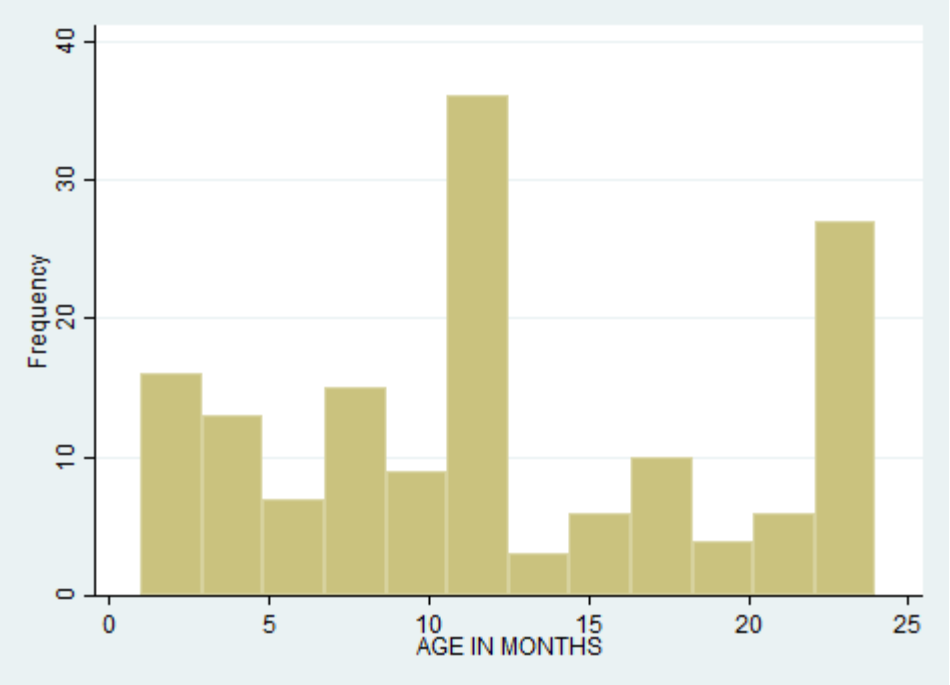


Figure 7 showing Age sex distribution (neonates excluded)

Age Sex distribution in different age groups.

Table 2 : showing age sex distribution in different age groups(neonates included)

Age group	Sex (%)	
	Male	Female
<1 month	7 (87.5)	1 (2.5)
1-6 months	24 (66.67)	12 (33.33)
6-12 months	53 (88.33)	7 (11.67)
12-24 months	50 (90.91)	5(9.09)

In all the age groups the number of males were higher than the females.

Mean Weight distribution in different age groups.

Table 3 : showing shows mean weight distribution in each age group.

Age Group	Mean weight in Kg (SD)
<1 month	2.99 (.65)
1-6 month	4.72 (1.52)
6-12 months	8.60 (2.15)
12-24 months	10.37 (1.71)

ASA Physical status classification

Table 3 : showing ASA physical status distribution of the patients. ASA Class (n= 159)

ASA Class	Frequency
Class I	139
Class II	20

Majority of the patients (139 out of 159) recruited into the study were of ASA physical status class I.

Distribution of diagnosis in study population.

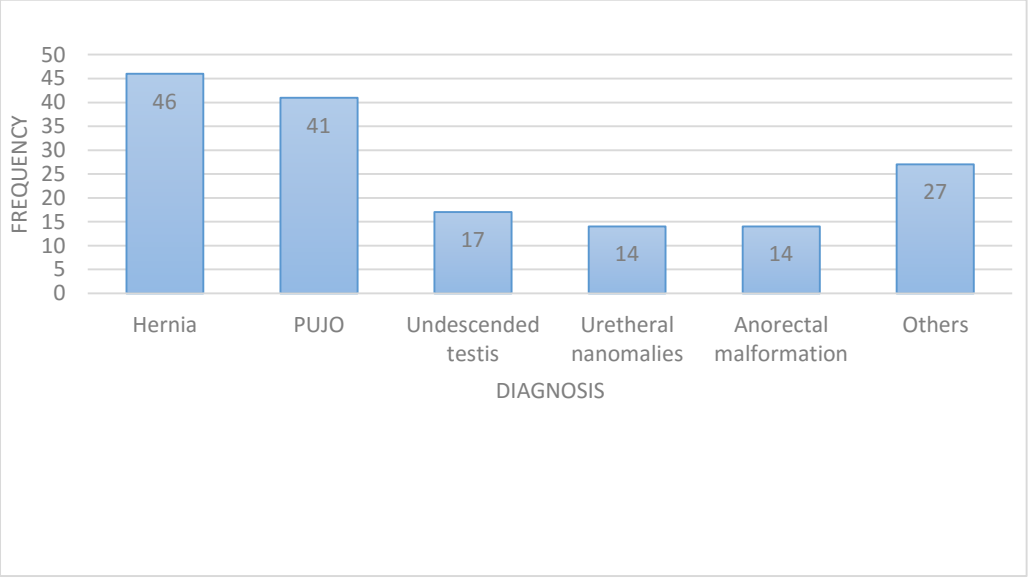


Figure 8 : showing distribution of diagnosis of the patients planned for surgery.

In the study population 118 patients (74%) underwent surgeries for urogenital anomalies.

Cutaneous Marker Data

Presence of Skin marker over the lumbosacral region in the study population.

Table 4 : showing presence of skin marker distribution in the study group

Skin Marker	Frequency (%)
Yes	41(25.78%)
No	118(74.21%)

In the study population, about 41patients (25%) had a skin marker over the lumbosacral region.

Type of Skin marker.

Table 5: showing types of skin marker distribution in patients with skin marker.

Type of cutaneous marker	Frequency (%)
Dimple	36(87.8%)
Deep Gluteal Fold	1(2.4%)
Nevus	1(2.4%)
Coccygeal pit	1(2.4%)
Cleft	2(4.8%)

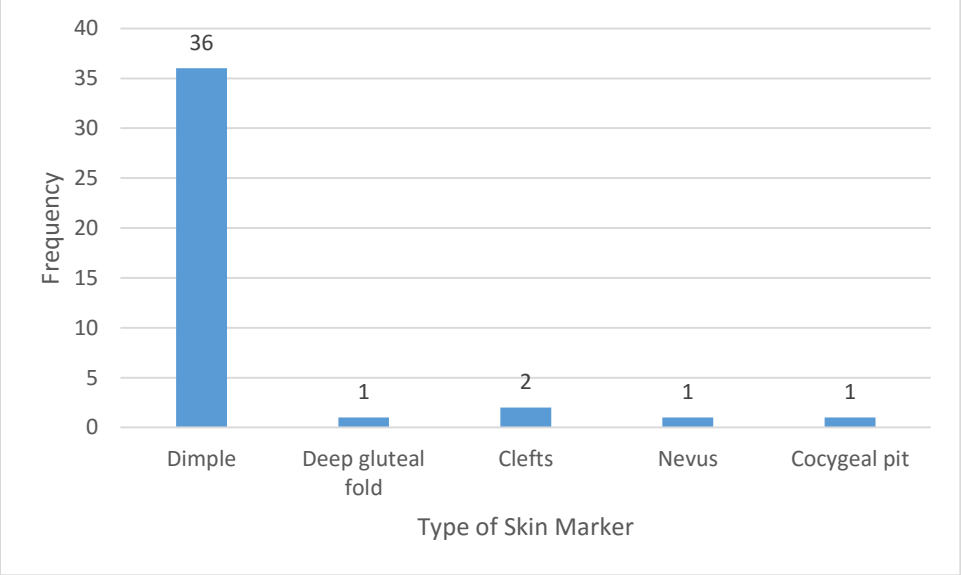


Figure 9: depicting distribution of types of cutaneous markers.(n=41)

Skin dimple was the most common marker seen in the group of patients having skin markers. Only one patient out of the 41 patients had an abnormal scan. There was no statistical significant association of cutaneous marker with abnormal ultrasound scan (p = 0.76)

Surface Anatomy Data

Surface anatomy relationship between the Posterior Superior Iliac Spines and the Sacral Hiatus.

Table 6: showing distribution of shape of triangle and frequency in the study population.

Shape of Triangle	Frequency (%)
Isosceles	126 (79.24%)
Equilateral	3 (1.8%)
Scalene	30 18.8%)

The posterior superior iliac spines and the sacral hiatus have a triangular relationship. In the study, the most common surface anatomy relation was that of an isosceles triangle followed by scalene and equilateral in children aged less than 2 years.

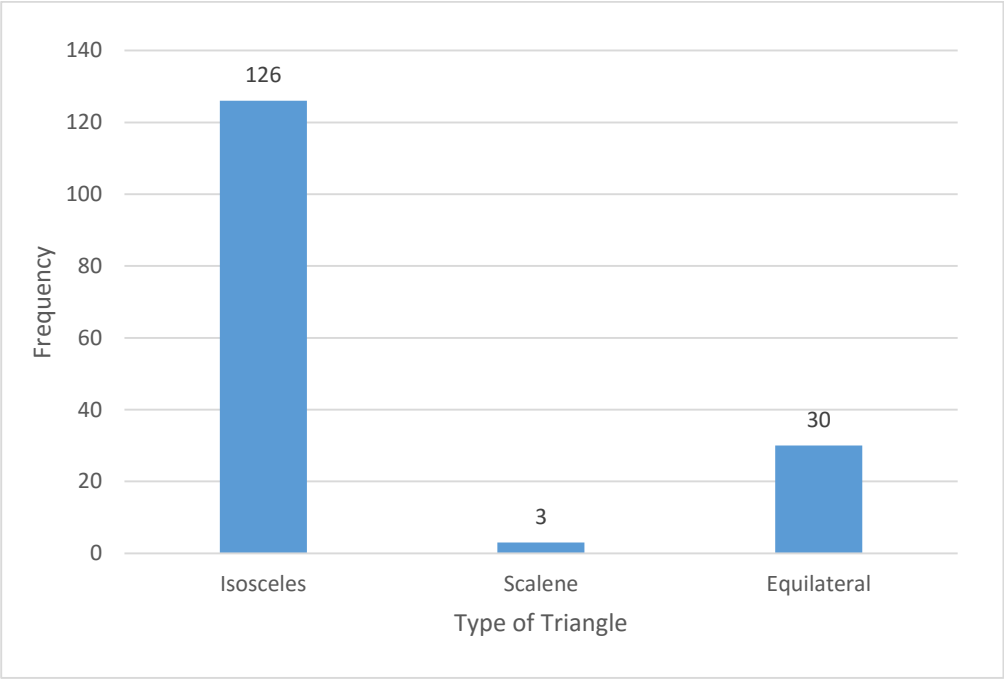


Figure 10: showing distribution of type of triangular surface anatomy relation in study population.

Surface Anatomy relation of Posterior Superior Iliac Spines and Sacral Hiatus in different age groups.

Table 7 : showing distribution of type of triangle in the different age groups.

Type of triangle	Age in months			
	<1 month	1-6 months	6-12 months	12-24 months
Isosceles	5	31	42	48
Equilateral	0	0	2	1
Scalene	2	5	16	7

Location of Sacral hiatus landmark correlation between surface anatomy by palpation and ultrasound screening.

Table 8 : depicting correlation of location of sacral hiatus by palpation and ultrasound.

Landmark same as Ultrasound	Frequency (%)
Yes	154 (96.85)
No	5 (3.15%)

The location of the sacral hiatus by palpation was corresponding to ultrasound scan location in 96.8% of patients.

Ultrasound data of Vertebral Levels at which spinal cord end in study population.

Table 9 : showing different vertebral levels at which spinal cord terminates.

Vertebral level	Frequency (%)
T12 Upper Border	8 (5.03%)
T 12 lower Border	23 (14.47%)
L 1 upper Border	36 (22.64%)
L1 Lower Border	49 (30.82%)
L2 Upper Border	28 (17.61%)
L2 Lower Border	7 (4.40%)
L3 Upper Border	7 (4.40%)
L5 Upper border	1 (0.63%)

The most common vertebral level at which the spinal cord ending was at the lower border of L1 vertebrae in the study population.

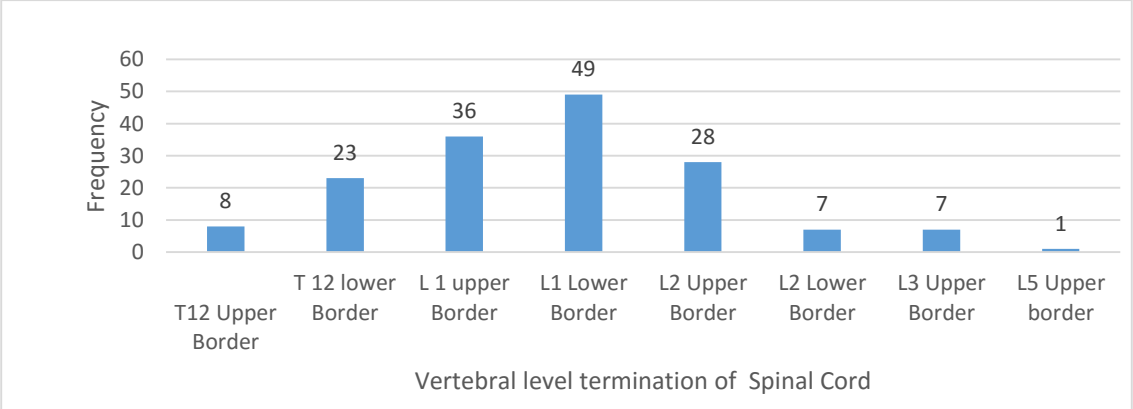


Figure 11 : showing the vertebral levels at which the spinal cord end in different age groups.

Vertebral levels at which spinal cord end in different age groups.

Table 10 : depicting different vertebral levels at which spinal cord ends in different age groups.

Level at which spinal cord end	<1month	1-6 months	6-12 months	12-24 months
T12 UB	0	1	5	2
T12 LB	0	1	11	11
L1 UB	0	8	9	19
L1 LB	1	10	22	16
L2 UB	2	11	10	5
L2 LB	3	2	2	0
L3 UB	1	3	1	2
L5 UB	0	0	0	1

The most common vertebral level at which spinal cord ends in age group of 1 month – 24 months was at the lower level of L1 vertebrae. While in neonates the spinal cord ends at a lower vertebral level corresponding to L2 vertebrae. One patient had a very low lying conus which suggested a tethered cord.

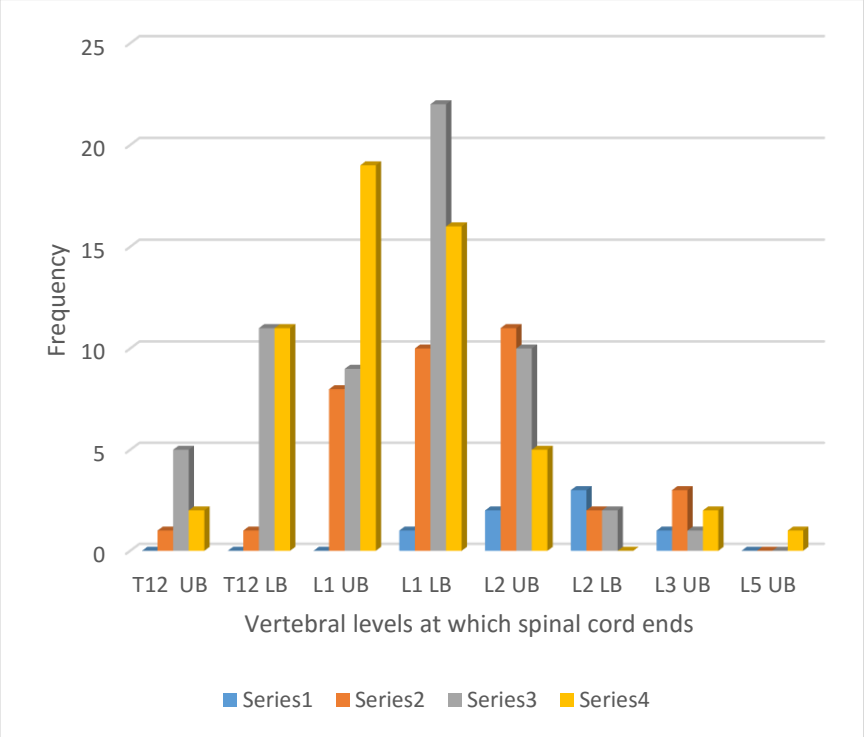


Figure 12 : showing the vertebral levels at which the spinal cord end in different age groups.

Ultrasound Data of vertebral levels at which dural sac ends.

Table 11 : depicting various vertebral Levels at which dura end in study population.

Vertebral levels at which dura end	Frequency (%)
L5Lower Border	7 (4.43%)
S1 Upper	22(13.92%)
S1 Lower Border	40(25.32%)
S2 Upper Border	66(41.77%)
S2 lower Border	14(8.86%)
S3 Upper Border	9(5.70)
S3 Lower Border	1(.006%)

The most common level at which dura terminates was at S2 upper border in the study population.

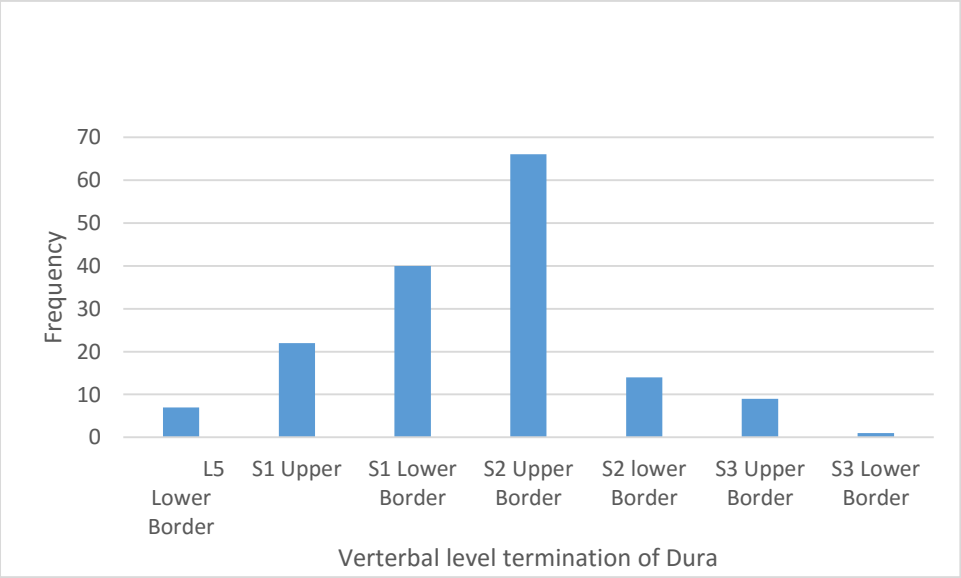


Figure 13 : showing different levels of termination of dural sac in stud population.

Ultrasound data of vertebral levels at which dura terminate in each age group.

Table 12 : vertebral levels at which dural sac end in each study group.

Level at which dura end	<1month	1-6 months	6-12 months	12-24 months
L5 LB	0	1	5	1
S1 UB	0	6	10	6
S1 LB	0	9	19	12
S2 UB	3	14	20	29
S2 LB	4	4	2	4
S3 UB	0	2	4	3

The most common vertebral level in age groups from 1 month – 24 months at which dura ends was at S2 upper border, while in neonates dural sac ended at lower level of S2 lower border. In 9 patients the dura ended at S3 upper border.

Thickness of Filum Terminale – Ultrasound Data

Table 13 : Age wise distribution of Filum Terminale thickness in study population.

Age groups	Mean thickness of Filum terminale in mm(SD)
<1 month	0.9 (0.2)
1-6 months	1.1 (0.3)
6-12 months	1.2 (0.3)
12-24 months	1.3 (0.3)

The thickness of Filum Terminale ranged from 5 - 23mm in all the patients. The mean was 12mm and SD - 3mm. In neonates the mean thickness was 0.9mm and SD was 0.2mm , in babies aged 1-6 months the mean thickness was 1.1mm and SD was0.3mm , in infants aged 6-12 months the mean thickness was 1.2mm and SD was 0.3, in patients aged 12-24 months the mean thickness was 1.3mm and SD was 0.3. Patients having thickness of filum terminale more than 2 mm was suspected to have Tethered cord.

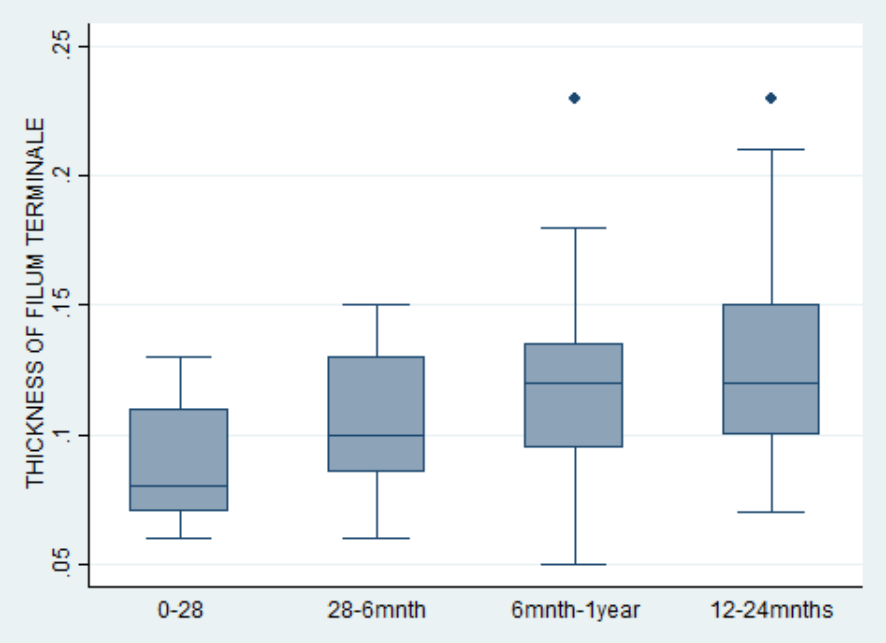


Figure 14 : Box plot showing mean thickness of filum terminale in the study population.

This figure explains that there was increase in thickness of Filum terminale with increase in age, which is statistically significant. (p value - 0.0019)

Ultrasound Data Cont'd

Table 14 : depicting mean values of various sonoanatomy measurements.

Variable	Mean Distance in cm (SD)
Distance between posterior Dura and CM	0.54 (.23)
Distance between skin and CM	1.55(0.39)
Distance between dura and skin	1.10(0.38)
Distance between Dura and FT	0.60(0.31)
Distance between skin and TFT	1.66(0.46)

The mean distance between posterior dura and conus medullaris was 0.54cm and SD 0.23cm. The mean distance skin and conus medullaris was 1.55cm and SD 0.39cm. The mean distance between dura and skin 1.10cm and SD 0.38cm. the mean distance between dura and filum terminale was 0.60cm and SD 0.31cm. The distance between skin and filum terminale was 1.66cm and SD 0.46cm.

Spinal cord Pulsations.

Table 15 : shows frequency distribution of spinal cord pulsations in study population.

Spinal Cord Pulsations	Frequency (%)
Yes	159(100%)

In all the 159 patients, spinal cord pulsations were present. The presence of spinal cord pulsations on ultrasound does not exclude the diagnosis of a tethered cord.

The ultrasound scan was termed abnormal if the following findings were present

1) Low Lying Spinal Cord (ending below 3rd Lumbar vertebral lower border)
2) Thickened Filum Terminale (more than 2mm)
3) Absent spinal cord pulsations
4) Low lying dura (below 3rd sacral vertebrae)
5) Presence of other abnormalities like Filar cyst, dermal sinus tracts communicating with the dura.

Out of 159 patients 5 patients had abnormal scans, one patient had low lying spinal cord, thickened Filum Terminale and a low lying dura.

Table 16 : Frequency distribution showing presence of ultrasound pulsations.

Features of abnormal scan	Frequency
Filar cyst	2
Low lying spinal cord	1
Thickened filum terminale	3
Low lying Dura	1

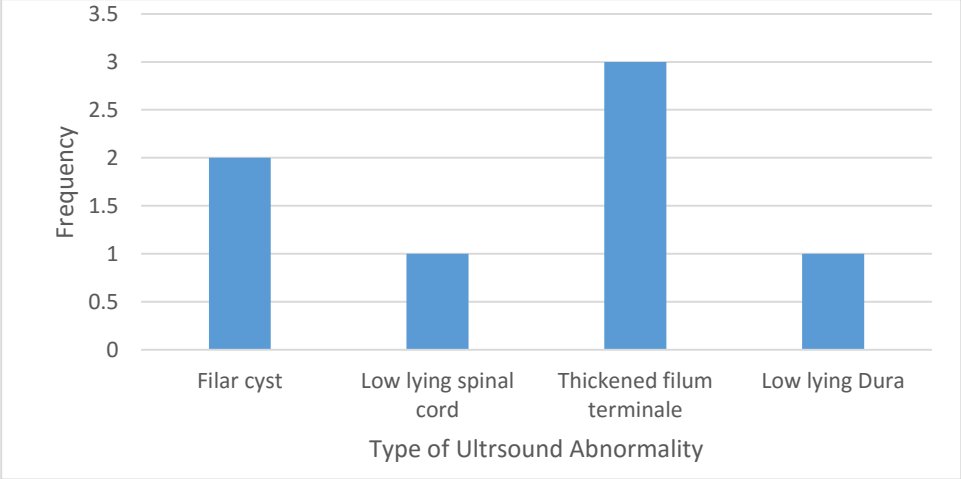
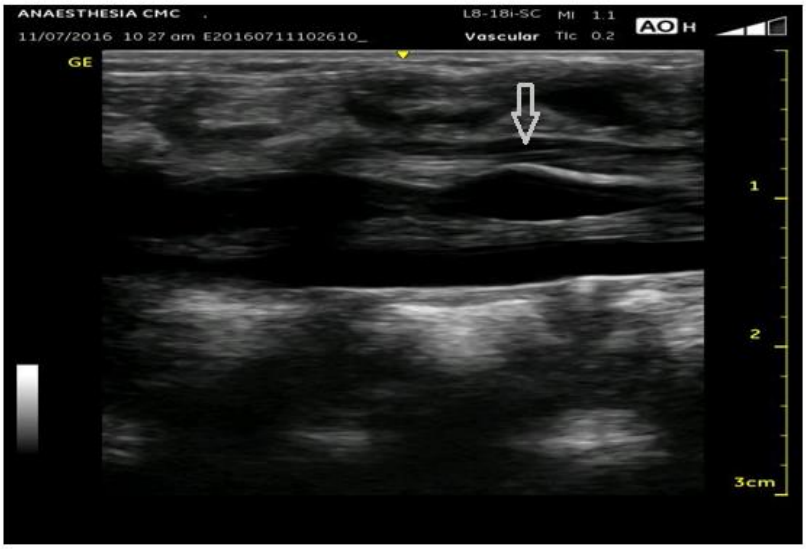


Figure 15 : Frequency distribution showing types of abnormal scan.

The prevalence of suspected occult spinal dysraphism was 3.1% which is higher than the prevalence in general population. This statistically insignificant (p-.35) but clinically significant.

Figure 16 showing filar cyst in first patient



Picture 17: showing Filar Cyst in second patient

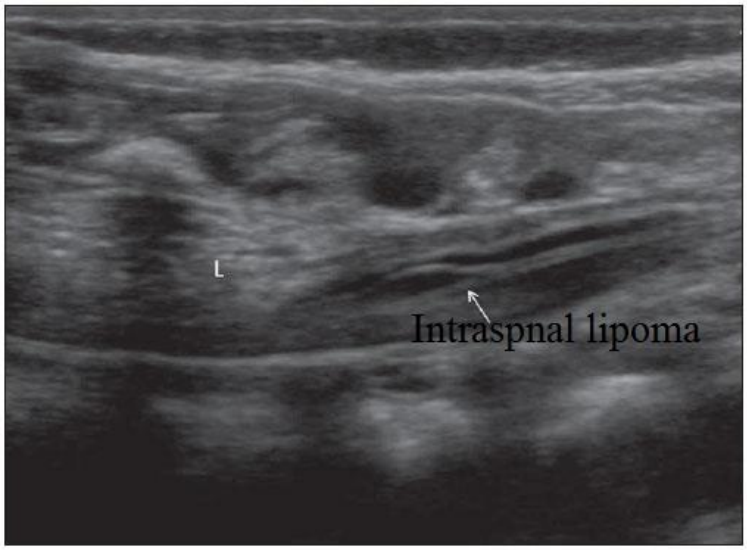


Figure 18: showing Intraspinal Lipoma - Tethered Cord Syndrome.

Depth of Sacrococcygeal membrane from skin – Ultrasound Data

Table 17 : showing the mean depths of sacrococcygeal membrane from skin.

Age Group	Mean depths in cms (S.D)
<1 month	0.43 (0.07)
1-6 months	0.67 (0.24)
6-12 months	0.66 (0.14)
12-24 months	0.67 (0.13)

The mean depth of sacrococcygeal depth from skin in older children was 0.66cm while in neonates it is 0.43cm.

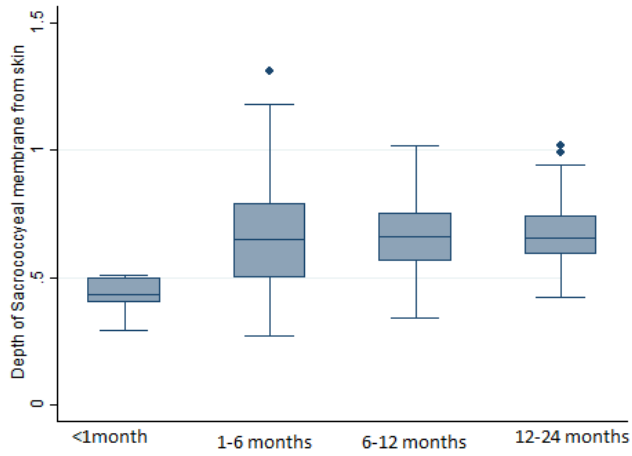


Figure 19 : Box plot showing depths of sacrococcygeal membrane from skin.

There is increase in depth of the sacrococcygeal membrane from the skin as age increases. It is important to note that the depth of the membrane and needle length in neonates while performing the caudal block

Mean Distance between lower end of dura and sacral hiatus. (SD)

Table 18 : it shows mean distance from lower end of dura and sacral hiatus in each age groups.

Age Group	Mean depth in cm (SD)
<1 month	2.23 (0.70)
1-6 months	2.49 (0.59)
6-12 months	3.04 (0.70)
12-24 months	3.45 (0.76)

The mean distance between the lower end point of dura and the sacral height increases with age. This improves the margin of safety while performing caudal block in older children from puncturing the meninges. This in not applicable in those with abnormal scan irrespective of the age unless done under real time ultrasound guidance.

DISCUSSION

DISCUSSION

Over a million paediatric patients undergo surgery around the globe each year. The successful outcome of surgery in children has been greatly attributed to special care, vigilant monitoring and safe anaesthetic practice. The anaesthetic plan commonly implemented is a combination of general and regional anaesthesia, which provides superior and long lasting analgesia intraoperatively and postoperatively. The several other advantages of regional block include no risk for respiratory depression, attenuation of perioperative surgical stress response, early extubation after major abdominal or thoracic surgery, decreased stay in intensive care unit and hospital, overall cost effectiveness.(32) Regional anaesthetic techniques in pediatric population has evolved over the last century from caudal based analgesia to peripheral nerve blocks and more of lumbar and thoracic epidurals. The ultrasound has captured an important place in the armamentarium of the anaesthesiologist for aiding vascular access and now being increasingly used for both peripheral and central neuraxial nerve blocks. The advent of ultrasound in regional anaesthesia has revolutionised the anaesthetic management with increase in safety and effectiveness of the block.(3)

The anomalies of these systems are commonly associated with occult spinal dysraphism due to the common embryological development.(33) Most often the unseen spinal anomalies are asymptomatic and involve the lumbosacral region. There are very scant literature showing perioperative ultrasound screening done by anaesthesiologists to rule out spinal anomalies prior to performing the block. Koo et al in their study of 259 patients aged less than 24 months recruited between 2007-2009, showed that 19 children had abnormal ultrasound scan. 4 out of the 19 children underwent detethering surgery.

They concluded that prevalence of occult spinal dysraphism in children with urogenital anomalies was higher than the general population, which warrants ultrasound evaluation of the spinal structures prior to performing central neuraxial block.(10) However, patients with anorectal anomalies were not recruited in their study. Anorectal malformations are also known to be associated with spinal anomalies.(34) Kim SM et al concluded from their study of 120 patients with anorectal malformation that prevalence of occult spinal dysraphism is high among patients with anorectal anomalies. Out of the 120 patients recruited, 41 patients had tethered cord and out of this cohort 26 patients underwent detethering surgery. Levit et al conducted a study on 934 patients having anorectal malformations of various types. 24% of the patients had suspected tethered cord and 18 patients underwent detethering surgery. They agreed with the recommendation that children with anorectal malformation need to undergo ultrasound screening of the spinal anatomy.(30) Teo et al conducted a retrospective study involving 101 patients diagnosed to have anorectal malformations who underwent surgery between 2002 and 2009.17 patients had low lying spinal cord and underwent further MRI imaging. Seven patients were diagnosed to have tethered cord. All seventeen patients underwent detethering as it was an instituitional protocol. They concluded that ultrasound was a beneficial tool as a first line screening tool to detect occult spinal anomalies in patients with anorectal malformations.(35) Scottoni et al concluded from their retrospective study of ultrasound screening of 244 patients with anorectal malformation aged less than 5 months, that ultrasound is necessary as a screening investigation to rule out occult spinal anomalies in children with anorectal malformations.(34) It is important for the anaesthesiologist to enquire whether children

with complex anorectal malformations have undergone ultrasound screening prior to surgery so as to plan for regional anaesthesia. If the screening results are not documented or available, it would be desirable to perform an ultrasound scan by the attending anaesthesiologist in the theatre to rule out occult spinal cord anomalies before proceeding with central neuraxial block. This enhance the safety of anaesthetic practise. There are no studies in Indian population done till date. Medina et al concluded from their study that sensitivity and specificity of ultrasound as a screening tool to detect occult spinal dysraphism was 86.5% and 92.9% respectively.(36) Kuo et al did a study to assess the relation of tethered cord in patients with VACTERL association by doing MRI scan in a cohort of 12 patients. They concluded from their study of 9(three patients got excluded) patients that that the incidence of tethered cord was significant (seven out of nine patients had abnormal i.e. about 77%) in those patients with anorectal malformations. The incidence of tethered cord was even higher in those with urogenital anomalies. The high incidence may be due to use of MRI to detect tethered cord and the characteristic group of patients having multi system anomalies.(8) In our study we have recruited patients with simple and complex urogenital anomalies and anorectal malformation. The prevalence was 3% which is higher than the prevalence in normal population which is 1-3/1000.(37) The results are statistically insignificant but clinically important as these patients may require regional anaesthesia for comfortable intraoperative and postoperative course. In our study we could not establish a significant relation between patients with anorectal malformation due to small patient population. The presence of abnormal scan was discussed with parents, treating unit, radiologists and neurosurgeons for the further plan of care. So performing a neuraxial block in such

patients without prior knowledge can be catastrophic. Hence it would be beneficial to do an ultrasound screening of the lumbosacral spine prior to the neuraxial block.

The presence of skin marker over the lumbosacral region is a relative contraindication for performing a neuraxial block. Anaesthesiologists are usually hesitant in proceeding with any central regional blocks in those with patients with cutaneous stigmata. There are several literature stating the fact that all types of cutaneous markers are not indicators of spinal dyraphism. Robinson et al from their study in 229 patients suggested that simple cutaneous markers like dimple were not sinister as a sole indicator of occult spinal dyraphism(27). Chern et al conducted a retrospective study of 973 children referred for lumbar ultrasound due to the presence of skin marker of occult spinal dysraphism. Only seven patients (0.007%) in the skin marker group and ten patients (0.057%) in the group having congenital anomalies had occult spinal dyraphism. They concluded that presence of skin markers are not reliable and were not conclusive of occult spinal dysraphism.(28). In our study, 41 patient had some skin marker and only one patient in this group had an abnormal scan. Neuraxial blocks were performed in this group safely as the ultrasound screening revealed normal anatomy. Hence it would be worthwhile doing a screening ultrasound scan when in doubt in the presence of a skin marker.

The surface anatomy knowledge of pediatric spine is important in order to perform neuraxial blocks. The anatomical relationship between the posterior superior iliac spines and the sacral hiatus is equilateral triangle in shape as mentioned in various studies. It is important to locate the right place for needle puncture as the placement of the needle in the caudal epidural space is paramount to avoid injury to the dura and

vessels. The location of the sacral hiatus may differ when compared to the accurate location seen on the ultrasound. Galente et al in their observational study of fifty children ages less than 1 year concluded that there was no statistical significant difference in location of sacral hiatus between palpation method and by ultrasound. (11) Abukawa et al concluded from their study on 282 patients that the surface anatomical relationship between posterior superior iliac spines and sacral hiatus was not equilateral in shape. They didn't specify the shape which majority of the patients had. They added that ultrasound was helpful in locating the sacral hiatus than by palpation alone.(38)The location of sacral hiatus can be difficult in obese patients and in patients with pre sacral pad of fat. The use of ultrasound in such patients is crucial in locating the sacral hiatus for the success and safety of the block.

Ultrasound enables to accurately locate the level at which the spinal cord and the dural sac ends with reference to the vertebral level. It becomes more difficult in older children due to the onset of ossification of the posterior arches. The information of the position of the spinal cord is critical in ruling out an underlying tethered cord. The vertebral levels at which the spinal cord ends varies with age. In neonates and infants the spinal cord ends at L1-L2 vertebral levels. In our study majority of the children had their spinal cord ending at lower border of L1 vertebrae and only 1 child had low lying spinal cord. The lower endpoint of dural sac is another valuable information among the various data obtained from ultrasound imaging of lumbosacral area. The lower level of dura varies with age. In neonates it can be as low as S4 vertebrae level and by infancy it ascends to S2 level. The presence low lying dura can be a normal anatomical variant or a pathological condition. Patients with anorectal malformations can have low lying dura

in the spectrum of occult spinal dysraphism. The anticipated problems of dural puncture while performing a caudal are total spinal anaesthesia associated with cardiorespiratory collapse, meningitis. Branislav Mislovi published a case report wherein real time ultrasound enabled to safely administer caudal block for a child who had a dura ending below the sacrococcygeal membrane planned for a posterior sagittal anorectoplasty. The knowledge of this abnormal sonoanatomy was paramount in performing caudal epidural block. Cohen et al published a case report wherein a child diagnosed with Trisomy 13 had an inadvertent dural puncture while performing caudal block.(39) MRI done later revealed occult spinal dyraphism. This catastrophe could have been avoided if a screening ultrasound was done in theatre by anaesthesiologist. Afshan et al published a case report wherein an 18 month old syndromic baby developed total spinal anaesthesia after caudal block using bupivacaine due to accidental dural puncture.(40) The block was performed using surface anatomy palpation alone. The authors have speculated that the cause might be due to abnormal sacral anatomy. It could have been beneficial if an ultrasound screening of the lumbosacral region was done especially in those with syndromes. In our study we had one patient with low lying dura with associated tethered cord. The ultrasound screening done by us in our study helped us in deciding whether to proceed with planned regional block, which contributes significantly to the safety of anaesthetic practise.

CONCLUSION

CONCLUSION

The prevalence of occult spinal dyraphism in children with urogenital and anorectal anomalies was 3% which is higher than the general population. The location of sacral hiatus as determined by surface landmark technique correlates well with that assessed by ultrasound. The surface anatomy relation between the posterior superior iliac spines and sacral hiatus was found to be predominantly isosceles triangle. Perioperative ultrasound screening of the lower spinal anatomy by anaesthesiologists done prior to performing neuraxial block is worthwhile in ruling out occult spinal anomalies in children requiring urogenital or anorectal surgeries thereby avoiding injury to the spinal structures thus enhancing safety in the practice of anaesthesiology.

LIMITATIONS

1) We recruited 159 patients to make up the alpha error of 4%. To have more accurate results, recruitment of patients will be continued even after submission for dissertation.
2) There was difficulty in clear visualisation of lower ends of the conus medullaris and filum terminale due to bony shadows.
3) Ultrasound available in our theatre is only 7 Hz so age recruited was till 2 years only.
4) All patients with suspicious scans could not be followed with MRI scans as surgeons dint agree or patient dint agree as payment had to be made.

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APPENDIX

Patient Information sheet

STATEMENT ABOUT THE RESEARCH

The Department of Anaesthesiology of Christian Medical College Hospital, Vellore is undertaking this research project to estimate the occurrence of undetected spinal cord problems in children admitted for surgery with kidney, reproductive organs and back passage problems using ultrasound scan machine. The subject's participation in this research study is voluntary. Refusal to participate will not involve any penalty or loss of benefits to which the subject is otherwise entitled and there will be no compromise in the quality of care the subject receives. The subject can choose to withdraw from the study at any time. Adequate measures will be taken to maintain the confidentiality of the subject's identity and the data collected and only those directly involved in the research will access the data as and when required.

1) Why is this research being done?

One of the most common cause for surgeries performed in children are for kidney, reproductive organs and back passage problems. or better pain relief, children admitted for surgeries done below the umbilicus are given general anaesthesia and an injection at the lower back in a bony gap above the natal cleft. Sometimes children with surgical problems of the kidney, reproductive organs and back passage region can have associated problems of the spinal cord which may not be visible on the skin outside. So in such children the injection at the back is not recommended as it may cause injury to the spinal cord or its coverings. So by doing ultrasound scan we will be able to detect the abnormality and thereby provide safe anaesthesia.

2) What is Ultrasound scan?

An ultrasound imaging is a safe and painless procedure that uses sound waves to make images of the structures inside the human body. This scan has no risk of any radiation exposure.

3) HOW WILL THIS RESEARCH BE DONE?

All children below the age of 2 years undergoing surgeries like hernia repair, reproductive organ surgeries, abnormalities of kidney and back passage will be participants in this study after informed consenting. All the patients will get the standard anaesthetic care as per the practice in this institution. So in this study after the child has become asleep, the child is made to lie on one side. Then we will examine the skin over the lower back followed by an ultrasound scan to see position of the spinal cord and its covering, measurements of depth from the skin. We will not proceed

with the injection if any abnormality is detected. All scans will be shown to ultrasound scan specialists. Any abnormality will be told to you and further treatment plans will be made after discussing with you and pediatric surgeons. Through this research we want to estimate the number of children having this unseen spinal cord problem using an ultrasound machine.

.4) DOES THE PATIENT NEED TO PAY FOR THE ULTRASOUND SCAN?

No. The cost involved for the scans will be provided by The Research Grant Fund at Christian Medical College Hospital Vellore.

5) HOW LONG WILL A SUBJECT NEED TO BE A PART OF THIS RESEARCH?

The patient will be part of the study only on the day of surgery. The scanning will be done as a single ultrasound scan.

6) IS THERE ANY RISK FOR THE SUBJECT BECAUSE OF THE RESEARCH?

There will be no risk for the patient because of the ultrasound scan as there is no radiation exposure.

7) WILL THERE BE ANY DISCOMFORT FOR THE SUBJECT?

Ultrasound scan is painless and will not cause any discomfort to the patient.

8) WILL THE SUBJECT HAVE ANY ADVANTAGE OR BENEFIT BECAUSE OF PARTICIPATING IN

THE STUDY?

There will not be any added advantage for the subject in terms of money or care given because of participation in this research.

PRIMARY INVESTIGATOR:

DR. NOVIN CHACKO JOHN

PG REGISTRAR DEPARTMENT OF ANAESTHESIOLOGY

Serial No. _____

Date_____

DATACOLLECTIONPROFORMA

Study title: A cross sectional study to estimate the prevalence of occult spinal dysraphism in children aged below 2years requiring urogenital and anorectal surgeries using ultrasound in operating room of a tertiary care hospital.

Demography

Age	
Sex	
Weight	
ASA grade	
Surgery planned	
Comorbidities	

Cutaneous markers present : Yes/No if yes, please encircle

Dimple/ tuft of hair/nevus/ Deviated gluteal fold/ Coccygeal pits/ pilonidal cysts/ others

Measurements of the triangular relation between the Two Posterior Superior Iliac Spines and the Sacral Hiatus

Distance between PSIS : _____cm

Sides of triangle	On SKIN	On USG
a)		
b)		

a-Right PSIS to sacral hiatus

b-Left PSIS to sacral hiatus

Type of triangle-Equilateral/Isosceles/Scalene

Does the landmark sacral hiatus palpated correspond to that seen on USG

Yes/No

MeasurementsonUSG

Conus Medullaris		
	Level	Spine level
	Post dura to CM	cm
	Skin to CM	cm
Dura		
	Level	Spine level
	Post dura to skin	cm
Filum terminale		
	Thickness of Filum terminale	cm
	Distance between Posterior dura to Filum terminale	cm
	Distance between Skin to Filum	cm
	Spinal cord pulsations	Yes/no

Comments:

Distance between lower end of dural sac and sacral hiatus :____cm

Depth of Sacrococcygeal Membrane from skin : _____ cm

Depth of Sacral hiatus from Sacrococcygeal Membrane : _____ cm

Format for Informed Consent Form for Subjects

Informed Consent form to participate in a research study

Study Title: Identification of unknown abnormal spinal conditions using ultrasound scan in children below 2 years undergoing surgeries for problems involving urinary and reproductive organs

Study Number: _____

Subject's Initials: _____
Subject'sName:_____

Date of Birth / Age: _____

(Subject)

(i) I confirm that I have read and understood the information sheet dated _____ for the above study involving my child and have had the opportunity to ask questions. [ ]

(ii) I understand that my participation in the study on behalf of my child is voluntary and that I am free to withdraw at any time, without giving any reason, without my child's medical care or legal rights being affected. [ ]

(iii) I understand that the Sponsor of the clinical trial, others working on the Sponsor's behalf, the Ethics Committee and the regulatory authorities will not need my permission to look at my child's health records both in respect of the current study and any further research that may be conducted in relation to it, even if I withdraw on behalf of the child from the trial. I agree to this access. However, I understand that my child's identity will not be revealed in any information released to third parties or published. [ ]

(iv) I agree not to restrict the use of any data or results that arise from this study provided such a use is only for scientific purpose(s). [ ]

(v) I agree to take part in the above study on behalf of my child. [ ]

Signature (or Thumb impression) of the Subject's parent/Legally Acceptable guardian

Date: _____/_____/_____ Relation:

Signatory's Name: _____ Signature:

Representative: _____

Date: _____/_____/_____

Signatory's Name: _____

Signature of the Investigator: _____

Date: _____/_____/_____

Study Investigator's Name: _____

Signature or thumb impression of the Witness: _____

Date: _____/_____/_____

Name & Address of the Witness: _____

For enquiries please contact

Dr Novin Chacko John

PG Rgistrar

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Mob : 7639280261 Off : 04162282105

Data Sheet

SNO	AGE	Agei	SEX	wt	DIAG	ASA	SP	Cl	TYPE	PSIS	UA	SA	UB	SB	shap	does	spin	Poste	skinto	lowe
1	7		1	7.2	5	2	rectal biopsy	1	coccyge	4.5	3	3	3	3	1	1	1	0.46	1.55	3
2	2		1	4	1	1	herniotomy	1	dimple	3.5	2	2	2.3	2.3	3	1	3	0.35	1.31	2
3	8		1	6	1	1	herniotomy	2		5	3.5	3.5	3	3	3	1	2	0.19	1.12	6
4	12		1	6.7	1	1	hernitomy	1	deep glu	4.5	3	3	3	3	1	1	1	1.38	3.8	1
5	12		1	8	1	1	hernia	2		5	4.5	4.5	4.5	4.5	1	1	4	0.38	1.38	3
6		8	1	4	2	1	Pyeloplasty	2		3.8	2	2	2.5	2.5	3	1	6	0.24	0.83	5
7	12		1	9	2	1	pyeloplasty	2		5	4.5	4.5	4.5	4.5	1	1	2	0.31	1.63	3
8	12		1	15	6	1	VU Reflux uret	2		6	5.2	5.2	5.2	5.2	1	1	4	0.56	1.55	4
9	12		1	8.3	6	1	cystoscopy PU	2		4.5	4.5	4.5	4.5	4.5	2	1	5	0.3	1.62	3
10	24		1	8.4	6	1	mitrofanoff+ b	2		5	3.8	3.8	3.8	3.8	1	1	1	0.32	1.44	2
11	24		1	10	2	1	pyeloplasty	1	dimple	4	3	3	3	3	1	1	2	0.1	1.41	1
12	8		2	7	2	1	pyeloplasty	1	dimple	5.2	4	4	2.5	2.5	3	1	1	0.21	1.5	1
13	12		1	8.6	6	1	DJ stent remov	2		5	3.6	3.6	3.6	3.6	1	1	2	0.35	1.43	2
14	18		1	10	2	1	Pyeloplasty	1	dimple	4.5	2.5	2.5	3.5	3.5	3	1	7	0.31	1.3	4
15	12		1	9	1	1	herniotomy	2		4	3	3	3	3	1	1	1	1	2.03	1
16	4		1	6.4	2	1	pyeloplasty	2		5	3.6	4	4	4	1	2	1	0.39	1.18	4
17	12		1	10	1	1	herniotomy	1	dimple	5.5	4.5	4.5	4.5	4	3	1	2	0.41	1.63	2
18	24		1	10	4	1	urethroplasty	1	cleft	5	3.3	3.3	3.3	3.3	1	1	1	0.44	1.86	3
19	4		1	4.5	2	2	cystoscopy pro	1	dimple	3	2.4	2.4	2.4	2.4	1	1	2	0.42	1.09	1
20	18		1	9.6	3	1	orchidopexy	1	dimple	5	4	4	4	4	1	1	2	0.42	1.46	2
21	12		1	9	3	1	orchidopexy	2		5	3.5	3.5	3.5	3.5	1	1	2	0.44	1.49	3
22	12		1	6	3	1	orchidopexy	2		5	3.6	3.6	4	4	3	1	2	0.77	2	1
23	16		1	12	4	1	circumcision	1	cleft	5.5	3.5	3.5	3.5	3.5	1	1	3	0.42	1.71	4
24	2		2	2.7	5	1	ASARP	2		3	2.5	2.5	2.5	2.5	1	1	5	0.34	0.99	4
25	7		1	6	6	1	PUV fulguratio	2		4	3	3	3	3	1	1	3	0.56	1.47	3
26	2		1	4	2	1	Cystoscopy	2		3.5	2	2	2	2	1	1	4	0.33	1.22	3
27	11		2	7.5	6	1	excision of Vit	2		4	2.5	2.5	2.5	2.5	1	1	4	0.57	1.63	3
28	7		2	5	5	2	sacroperineal p	1	dimple	4.2	3.5	3.5	3.5	3.5	1	1	6	0.56	1.53	6
29	18		1	10	3	1	orchidopexy`	2		5.5	4	4	4	4	1	1	3	0.61	1.67	4
30	9		2	8.5	1	1	hernioplasty	2		5	4	4	3.5	3.5	3	1	4	0.66	1.63	2
31	8		1	10	2	1	nephrectomy	2		4	3	3	3	3	1	1	5	0.44	1.38	4
32	14		1	8	6	2	uretric reimpla	2		5	3.5	3.5	3.5	3.5	1	1	7	0.55	1.58	4
33	12		1	11	2	1	pyeloplasty	1	dimple	5.5	4	4	3.5	3.5	3	1	2	0.58	1.79	3
34	12		1	11	2	1	DJ Stenting	2		4.5	3.2	3.2	3.2	3.2	1	1	1	0.76	1.78	2
35	8		1	7	2	1	DJ stent remov	1	dimple	4.6	3	3	2.5	2.5	3	1	5	0.45	1.36	4
36	18		1	11	3	1	orchidopexy	2		5.5	3.5	3.5	3.5	3.5	1	2	2	0.64	1.96	4
37	16		1	10	1	1	herniotomy	2		5	3.5	3.5	3.5	3.5	1	1	2	0.57	1.78	3
38	18		2	11	1	1	cystoscopy	2		6.5	4.2	4.2	4.2	4.2	1	2	3	0.75	2.07	6
39	4		2	6.9	5	1	ASARP	2		5.9	4	4	4	4	1	1	3	0.26	1.42	3
40	21		1	10	1	1	herniotomy	2		5.5	4	4	4	4	1	1	3	0.47	1.57	2
41	24		1	11	4	1	urethroplasty	2		6.5	4.5	4.5	4.5	4.5	1	1	3	0.52	1.75	3
42	19		1	9.2	6	1	PUV fulguratio	2		5.5	4	4	4	4	1	1	4	0.74	1.88	4
43	19		1	11	6	1	ureteral reimol	2		5	3.5	3.5	3.5	3.5	1	1	4	0.57	1.69	2
44	10		1	8.2	6	2	hirschsprungs d	1	1	5	4	4	4	4	1	1	2	0.5	1.63	1
45	10		1	7	6	1	cystoscopy circ	2		5.5	4	4	4	4	1	1	5	0.36	1.72	4
46	8		1	5.2	1	1	herniotomy	2		4.5	3	3	3	3	1	1	2	0.27	1.15	2
47	5		2	6.4	5	1	ASARP	2		4	3	3	3	3	1	1	3	0.63	1.54	4
48	24		1	11	4	1	urethroplasty	2		5.5	4	4	4	4	1	1	2	0.24	1.58	4
49	2		1	4.3	1	1	hernitomy	2		4	3	3	3	3	1	1	4	0.22	1.01	3
50	18		1	8	1	1	hernitomy	2		5.5	4	4	4	4	1	1	5	0.48	1.5	5
51	24		1	7.6	2	1	Pyeloplasty	2		6	5.5	5.5	5.5	5.5	1	1	3	0.35	1.52	3
52	4		1	6	2	1	nephrectomy	1	dimple	4.5	3.5	3.5	3.5	3.5	1	1	3	0.67	1.44	3
53	14		1	7	6	2	hirschsprung di	1	dimple	4.5	3	3	3	3	1	1	4	0.46	1.45	5
54	12		1	9	6	1	PUV fulguratio	2		5	3	3	3.5	3.5	3	1	4	0.36	1.35	4
55	18		1	9	1	1	Herniotomy	1	dimple	4.5	3.5	3.5	3.5	3.5	1	1	3	0.48	1.61	4
56	21		1	10	2	1	cystoscopy	2		5.5	3.5	3.5	3.5	3.5	1	1	2	0.46	1.56	3
57	12		1	9	3	1	orchidopexy	2		5.5	3.5	3.5	3.5	3.5	1	1	4	0.62	1.62	2
58	16		1	8.6	6	1	nephrouretrect	2		4.5	3.5	3.5	3.5	3.5	1	1	4	0.76	1.8	4
59	18		1	9.6	1	1	herniotomy	2		6	4	4	4	4	1	1	5	0.63	1.77	6
60	3		1	5.9	2	1	pyeloplasty	2		4.2	3	3	3	3	1	1	4	0.39	1.27	5
61	12		1	7.2	6	1	diagnodtic lapa	2		5.5	3.5	3.5	3.5	3.5	1	1	6	0.39	1.48	2
62		12	1	3.4	1	1	herniotomy	1	dimple	4	3	3	3	3	1	1	5	1.29	1	4

posteri	TFT	posteri	depthos	spir	distar	depthofs	Depthofs	scanne	typeofabnormalityse
1.18	0.12	0.34	1.21	1				1	
0.9	0.1	0.42	1.28	1			2	1	
0.88	0.05	0.26	1.15	1			2.8	1	
0.29	0.09	2.9	4.8	1			3	1	
1	0.09	0.29	1.27	1	0.7	0.34	4	1	
0.79	0.1	0.27	0.96	1	1.6	0.4	0.35	1	
1.52	0.13	0.78	2.27	1	3	0.75	0.35	1	
0.89	0.09	0.24	1.1	1	3.5	0.7	0.55	1	
1.32	0.06	0.3	1.07	1	4			1	
0.92	0.07	0.32	1.27	1	3.5			1	
1.3	0.08	0.18	1.48	1	2.6	0.63	0.36	1	
1.29	0.12	0.34	1.61	1				1	
1.23	0.15	0.65	1.84	1	3.4	0.48	0.55	1	
1.14	0.12	1.63	1.83	1	2.5	0.76	0.36	1	
1.17	0.17	0.76	1.83	1	3.4	0.56	0.6	1	
0.88	0.13	0.61	1.48	1	3	1.31	0.27	1	
1.27	0.16	0.55	1.78	1	4	0.56	0.8	1	
1.42	0.15	0.34	1.43	1	3.2	0.58	0.5	1	
0.82	0.1	0.45	1.17	1	2.6	0.46	0.32	1	
1.19	0.08	0.69	1.82	1	3.6	0.5	0.31	1	
1.13	0.17	0.84	1.99	1	3	0.98	0.68	1	
1.23	0.13	0.89	2.29	1	3.8	0.57	0.44	1	
1.38	0.19	0.77	2.17	1	3.8	0.65	0.67	1	
0.76	0.08	0.15	1.12	1	2.2	0.68	0.62	1	
1.01	0.09	0.69	1.71	1	2.5	0.56	0.44	1	
0.92	0.12	0.41	1.3	1	1.8	0.65	0.44	1	
1.32	0.11	0.39	1.53	1	2.2	0.78	3.4	1	
0.99	0.13	0.53	1.53	1	2.2	0.74	0.32	1	
1.19	0.17	0.61	1.67	1	2.5	0.57	0.33	1	
1.01	0.11	0.67	1.68	1	3.2	0.75	0.43	1	
0.93	0.15	0.47	1.51	1	3.4	0.6	0.54	1	
0.99	0.12	0.45	1.5	1	4.5	0.69	0.28	1	
1.47	0.08	0.65	1.98	1	4	0.87	0.45	1	
1.16	0.17	0.95	2.02	1	3.8	0.77	0.62	1	
0.8	0.13	0.41	1.28	1	2.5	0.63	0.26	1	
1.31	0.11	0.5	1.79	1	4.2	0.92	0.58	1	
1.2	0.12	0.6	1.86	1	4.5	0.72	0.66	1	
1.52	0.15	0.54	0.81	1	3.6	0.99	0.63	1	
1.33	0.13	0.26	1.52	1	3	0.82	0.54	1	
1.17	0.15	0.62	1.78	1	3	0.53	0.46	1	
1.31	0.23	0.54	1.83	1	4.2	0.77	0.48	2	2
1.39	0.12	0.51	1.79	1	4.5	0.6	0.49	1	
1.33	0.13	0.64	1.86	1	3	0.72	0.45	1	
1.14	0.17	0.54	1.74	1	3.5	0.61	0.48	1	
1.43	0.11	0.29	1.65	1	4	0.9	0.31	1	
1.08	0.1	0.7	1.58	1	2.8	0.68	0.5	1	
0.92	0.14	0.58	1.51	1	2.6	1.18	0.41	1	
1.57	0.15	0.73	2.07	1	3	0.61	0.39	1	
0.8	0.14	0.33	1.08	1	2.6	0.79	0.31	1	
1.08	0.17	0.51	1.7	1	3.5	0.43	0.49	1	
1.79	0.14	0.52	1.79	1	4.5	0.79	0.78	1	
0.99	0.12	0.59	1.55	1	1.6	0.85	0.66	1	
0.98	0.15	0.6	1.58	1	2.6	0.59	0.4	1	
0.96	0.14	0.47	1.55	1	2.5	0.75	0.34	1	
1.34	0.11	0.55	1.77	1	1.7	0.62	0.54	1	
1.24	0.18	1.79	2.03	1	3	0.79	0.56	1	
1.01	0.12	0.72	1.89	1	2.8	0.76	0.47	1	
1.03	0.18	0.71	1.87	1	3	0.63	0.58	1	

63	12		2	9.6	5	1	PSARP	1	DIMPL	5.5	4	4	3	3	3	1	4	0.53	1.79	2
64	8		1	8	6	1	puv fulguration	1	dimple	4	3.5	3.5	3.5	3.5	1	1	5	0.87	1.62	5
65	4		2	5.8	2	1	pyeloplasty	2		4.9	2.9	2.9	2.5	2.5	3	1	5	0.21	1.26	2
66	3		1	4	6	1	puv fulguration	2		4.6	3.9	3.9	3.9	3.9	1	1	4	0.48	1.35	4
67	19		1	11	2	1	ureteric reimpl	2		5	3.5	3.5	3.5	3.5	1	1	4	0.47	1.5	3
68	2		2	3.8	5	1	ASARP	2		5	4.5	4.5	4	4	3	1	6	0.2	1.01	6
69	10		1	7.6	3	1	orchidopexy	1	dimple	4	3	3	3	3	1	1	5	0.38	1.39	3
70	24		1	10	1	1	herniotomy	2		5.5	4	4	4	4	1	1	5	0.44	1.57	6
71	16		1	11	2	1	cystoscopy and	1	dimple	5.5	3.5	3.5	3.5	3.5	1	1	4	0.77	1.79	4
72	8		1	10	1	1	herniotomy	2		6	4	4	4	4	1	1	3	0.61	1.7	3
73	12		1	10	2	1	ureteric reimpl	2		5.5	4	4	3.5	3.5	3	1	4	0.53	1.63	4
74	12		1	8.5	4	1	urethroplasty	2		5	4	4	4	4	1	1	2	0.69	1.61	2
75	18		1	9.2	1	1	herniotomy	2		5	4	4	4	4	1	1	3	0.41	1.44	3
76	21		2	9	2	1	pyeloplasty	2		5.5	5	5	5	5	1	1	5	0.84	1.87	4
77		12	1	3.1	5	2	colostomy	2		3.5	3	3	3	3	1	1	6	0.52	1.18	5
78		10	1	3	6	2	PUV with renl	1	dimple	3	3.5	3.5	2.5	2.5	3	1	6	0.33	0.91	4
79	24		1	10	2	1	pyeloplasty	2		6	5	5	5	5	1	1	2	0.72	2.09	4
80	8		1	5	2	1	pyeloplasty	1	dimple	5	4.1	4.1	4.1	4.1	1	1	4	0.74	1.62	4
81	12		1	10	1	1	herniotomy	2		6.2	5.2	5.2	5.2	5.2	1	1	4	0.7	1.9	3
82	12		1	9	1	1	herniotomy	2		5.5	4.3	4.3	4.3	4.3	1	1	5	0.58	1.9	3
83	24		1	12	6	1	umblical explor	2		6.5	5.5	5.5	5.5	5.5	1	1	4	0.53	2.38	4
84	16		2	8	2	1	nephrectomy	2		6	5	5	4.5	4.5	3	1	2	0.77	2.07	3
85	15		1	11	1	1	herniotomy	2		6	5.5	5.5	5.5	5.5	1	1	5	0.43	1.87	4
86	24		2	13	2	1	DJ stent excha	2		7	4.5	4.5	4.5	4.5	1	1	3	0.48	1.69	4
87	24		1	11	2	1	cystoscopy	2		5.5	4	4	4	4	1	1	4	0.35	1.56	2
88	24		1	15	2	1	Pyeloplasty	2		5.5	4.5	4.5	4.5	4.5	1	1	3	0.65	1.73	4
89	2		1	5	6	1	umblical explor	2		4.5	3	3	3	3	1	1	5	0.49	1.28	2
90	12		1	11	3	1	orchidopexy	2		5.8	4.5	4.5	5.5	5.5	3	1	2	0.4	1.65	4
91	12		1	11	1	1	herniotomy	2		6	4.5	4.5	4.5	4.5	1	1	3	0.95	2.23	3
92	6		1	4.2	2	1	ureterostomy	2		4	3	3	3	3	1	1	5	0.54	1.22	4
93	8		1	9	3	1	orchidopexy	2		4.5	3.5	3.5	3.5	3.5	1	1	4	0.62	1.43	3
94	12		1	15	1	1	herniotomy	2		6.5	5.5	5.5	5	5	3	1	3	0.99	2.25	4
95	6		1	8	2	1	ureter explorat	1	dimple	4	2.5	2.5	2.5	2.5	1	1	4	0.45	1.46	5
96	24		1	9	1	2	herniotomy	2		6	5	5	5	5	1	1	3	0.88	1.98	2
97	24		1	10	1	1	herniotomy	1	dimple	6.2	4.5	4.5	5.5	5.5	3	1	2	0.92	2.27	4
98	24		1	11	2	1	DJ stenting	2		6	5.2	5.2	5.2	5.2	1	1	3	0.99	1.98	5
99	5		1	5.7	2	1	pyeloplasty	2		4.5	3	3	3	3	1	1	4	0.85	2.08	4
100	24		1	9.4	1	1	Urethroplasty	2		6.5	5.5	5.5	5	5	3	1	3	0.84	1.92	4
101	12		1	8.4	3	1	orchidopexy	1	dimple	6.5	5	5	5	5	1	1	4	0.66	1.73	3
102	1		1	5	5	1	Pull through	2		5.5	4.6	4.6	4.6	4.6	1	1	3	0.55	1.38	3
103	2		1	5.2	2	1	Pyeloplasty	2		3.5	3	3	3	3	1	1	3	0.55	1.26	3
104	8		1	6.6	2	1	pyeloplasty	2		5	4	4	4	4	1	1	4	0.62	1.62	4
105	2		1	5	2	1	Cystoscopy	2		3.9	2.5	2.5	2.5	2.5	1	1	5	0.47	1.24	5
106	8		1	7.4	1	1	herniotomy	1	dimple	3.5	2.5	2.5	2.5	2.5	1	1	4	0.67	1.64	4
107	2		1	3.5	1	1	herniotomy	2		3.5	2	2	2	2	1	1	7	0.38	1.12	6
108	24		1	12	2	1	Pyeloplasty	2		6	6	5.5	5.5	5.5	1	1	4	0.8	1.22	5
109	22		1	14	3	1	orchidopexy	2		5.5	4.5	4.5	4.5	4.5	1	1	4	0.76	1.86	4
110	12		1	9	2	1	Pyeloplasty	2		6	5.4	5.4	5.4	5.4	1	1	3	0.99	2.01	3
111	24		1	14	5	1	colostomy clos	2		5.5	4	4	4	4	1	1	4	0.44	1.56	3
112	2		1	5.5	6	1	?urachus umbli	2		4.5	3	3	3	3	1	1	5	0.49	1.29	4
113	11		1	11	2	1	DJ stent exit st	2		5.5	4	4	4.5	4.5	3	1	4	0.75	1.83	2
114	19		1	12	4	1	urethroplasty	2		6.2	5.5	5.5	5.5	5.5	1	1	4	0.8	1.97	4
115	7		1	5	4	2	Pull through	2		4.2	3	3	3	3	1	1	3	0.33	1.28	6
116	3		1	5	1	1	Herniotomy	2		6	5	5	5	5	1	1	5	0.76	1.88	4
117	3		2	5	1	1	herniotomy	2		4	3.5	3.5	3.5	3.5	1	1	4	0.58	1.2	4
118	12		1	9	4	1	circumcision	2		5	3	3	3	3	1	1	4	0.42	1.62	4
119	24		1	10	5	2	pull through Hi	2		6	5.5	5.5	5.5	5.5	1	1	3	0.89	2.27	4
120	12		1	8	6	1	Extrophy Blad	2		4.5	3.5	3.5	3.5	3.5	1	1	4	0.42	1.55	4
121	11		2	7.5	2	1	Pyeloplasty	1	Dimple	5.5	5	5	5	5	1	1	4	0.99	1.49	4
122	9		2	5.2	5	2	colostomy clos	2		5	3	3	3	3	1	1	4	0.46	1.22	4
123	12		1	10	4	1	Urtehroplasty	1	Dimple	6.5	5.5	5.5	5	5	3	1	4	0.76	1.03	4
123	24		1	10	3	1	orchidopexy	2		7	4.5	4.5	5	5	3	1	3	0.59	1.81	4
125	12		1	13	3	1	orchidopexy	2		6	4	4	4	4	1	1	3	0.58	1.95	5

1.53	0.11	0.38	1.7	1	2.5	0.71	0.79	1	
0.79	0.1	0.96	1.91	1	2.6	0.51	0.46	1	
0.97	0.07	0.31	1.34	1	2.5	0.93	0.47	1	
0.85	0.08	0.57	1.52	1	2.5	0.66	0.24	1	
1.46	0.08	0.55	2.26	1	3	0.67	0.22	1	
0.9	0.08	0.44	1.32	1	2	0.51	0.25	1	
1.25	0.12	0.59	1.68	1	3.5	0.66	0.49	1	
1.13	0.12	0.53	1.77	1	4	0.67	0.39	1	
1.05	0.12	0.87	2.06	1	3.5	1.02	0.58	1	
1.13	0.11	0.74	1.91	1	3.5	1.02	0.4	1	
1.1	0.12	0.66	1.85	1	3	0.72	0.45	1	
0.91	0.08	0.88	1.83	1	2.4	0.75	0.32	1	
1.18	0.13	0.68	1.71	1	3.2	0.63	0.31	1	
1.03	0.08	0.8	1.81	1	3.5	0.55	0.33	1	
0.65	0.13	0.37	0.99	1	2.2	0.5	0.93	2	1
0.58	0.11	0.49	1.04	1	3	0.41	0.29	1	
1.34	0.09	0.72	2.28	1	3.8	0.7	0.54	1	
0.96	0.11	0.73	1.67	1	3.6	0.51	0.37	1	
1.11	0.11	0.71	1.93	1	3.4	0.74	0.49	1	
1.3	0.12	0.61	1.87	1	3.6	0.74	0.31	1	
1.86	0.09	0.6	2.42	1	3.8	0.85	0.55	1	
1.22	0.11	0.6	1.93	1	3.5	0.66	0.69	1	
1.44	0.15	0.62	1.64	1	3.4	0.64	0.39	1	
1.32	0.16	0.79	2.13	1	3.8	0.55	0.45	1	
1.26	0.11	0.68	2	1	3.7	0.57	0.43	1	
1.08	0.11	0.88	2.1	1	5.5	0.59	0.39	1	
0.79	0.07	0.61	1.35	1	3.4	0.77	0.3	1	
1.29	0.18	0.63	2.12	1	3	0.52	0.48	1	
1.21	0.12	1.01	1.92	1	3	0.59	0.51	1	
0.67	0.09	0.4	1.17	1	2.5	0.5	0.46	1	
0.85	0.11	0.75	1.58	1	2.6	0.85	0.46	1	
1.29	0.15	1.31	2.18	1	3	0.58	0.42	1	
1	0.14	0.63	1.69	1	3	0.75	0.58	1	
4	0.09	0.7	2.07	1	3.6	0.72	0.45	1	
1.28	0.09	0.58	1.67	1	3.5	0.94	0.55	1	
1.1	0.12	1.06	2.28	1	4	0.86	0.55	1	
1.29	0.15	0.67	2.05	1	3.5	0.84	0.57	1	
1.08	0.14	0.9	1.88	1	3.8	0.51	0.45	1	
1.07	0.09	0.86	2	1	3.5	0.46	0.34	1	
0.84	0.14	0.5	1.4	1	3	0.55	0.35	1	
0.7	0.15	0.73	1.43	1	3	0.55	0.4	1	
0.96	0.12	0.88	1.88	1	3.2	0.74	0.85	1	
0.74	0.1	0.57	1.34	1	2.5	0.47	0.49	1	
1.04	0.13	0.87	1.88	1	1.5	0.69	0.65	1	
0.77	0.07	0.37	1.19	1	2.2	0.75	0.36	1	
1.4	0.13	0.72	2.3	1	3.8	0.74	0.87	1	
1.11	0.1	0.72	1.93	1	3.5	0.49	0.3	1	
1.06	0.13	0.55	1.71	1	4	0.54	0.4	1	
1.22	0.12	0.54	1.78	1	4	0.61	0.3	1	
0.59	0.1	0.52	1.34	1	2.5	0.57	0.34	1	
1.22	0.17	0.88	1.97	1	3.2	0.56	0.36	1	
1.2	0.1	0.62	2.14	1	4	0.69	0.48	1	
0.77	0.09	0.56	1.49	1	3.5	0.47	0.28	1	
1.12	0.11	0.64	1.75	1	4	0.44	0.38	1	
0.62	0.13	0.53	1.13	1	2.6	0.52	0.55	1	
1.42	0.11	0.32	1.65	1	2.8	0.95	0.68	1	
1.37	0.1	0.8	2.17	1	4	0.6	0.58	1	
1.25	0.12	0.52	1.67	1	3	0.55	0.5	1	
0.49	0.09	0.46	1.68	1	4.2	0.46	0.48	1	
0.81	0.09	0.51	1.27	1	2.8	0.45	0.44	1	
0.76	0.14	0.9	2.02	1	3.5	0.65	0.51	1	
0.78	0.11	0.65	1.91	1	3.5	0.69	0.43	1	
1.37	0.14	0.42	2.03	1	1.7	0.81	0.53	1	

126	5		1	5.5	2	1	Nephrectomy	2		3.7	3	3	3	3	1	1	6	0.57	1.42	4
127		4	1	2.4	4	1	PUV fulguratio	2		3.5	3	3	3	3	1	1	5	0.39	0.86	4
128	5		2	7	4	1	Genotoscopy	1	Dimple	5	4	4	4	4	1	1	4	0.75	1.76	3
129		2	2	3	2	2	colostomy	2		3.5	2.7	2.7	2.7	2.7	1	1	7	0.46	1.09	5
130	12		1	11	3	1	Orchidopexy	2		5.5	3.5	3.5	3.5	3.5	1	1	5	0.84	1.7	4
131	3		1	1.7	1	2	Herniotomy pr	2		3.5	2.8	2.8	2.8	2.8	1	1	7	0.31	0.71	3
132	2		2	1.9	1	2	herniotomy Pr	1	dimple	2.7	2.5	2.5	2	2	3	1	7	0.19	0.69	4
133	9		1	9.7	3	1	orchidopexy	2		5.5	5	5	4	4	3	1	5	0.73	1.93	4
134	9		1	11	1	1	Herniotomy	1	dimple	5	5	5	5	5	2	1	4	0.38	1.3	4
135	9		1		5	1	imperforate an	2		6	5	5	4.6	4.6	3	1	7	0.57	1.58	6
136	24		1	14	4	1	Urethroplasty	1	Dimple	6.5	5.5	5.5	5.5	5.5	1	1	2	0.51	1.67	3
137	2		2	1.7	1	2	herniotomy Pr	2		3.5	2.5	2.5	2.5	2.5	1	1	5	0.25	0.75	4
138	12		1	8	1	1	herniotomy	2		7.5	5	5	5	5	1	1	4	0.88	1.87	3
139	5		2	7	6	1	Extrophy blad	2		5.5	4	4	4	4	1	1	3	0.49	1.35	5
140	21		1	11	4	1	Urethroplasty	2		5.5	3.5	3.5	3.5	3.5	1	1	4	0.43	1.66	4
141	3		2	2.5	1	1	herniotomy	1	Dimple	4.5	3.5	3.5	3.5	3.5	1	1	5	0.36	0.91	4
142	18		2	7.5	1	1	Herniotomy	2		6	4.5	4.5	4.5	4.5	1	1	3	0.47	1.56	4
143	24		1	12	1	1	herniotomy	2		7.5	5.5	5.5	5.5	5.5	2	1	3	1.2	1.89	3
144	24		1	12	1	1	hernia	2		6	4	4	4.5	4.5	3	1	4	0.66	1.94	4
145	9		1	9	3	1	orchidopexy	2		5	3.5	3.5	3.5	3.5	1	1	3	0.46	1.49	3
146	21		1	11	6	1	circumcision	1	dimple	6.8	5	5	5	5	1	1	8	0.14	0.98	
147	2		1	4	1	1	herniotomy	2		4	3.5	3.5	3.5	3.5	1	1	5	0.31	1.17	4
148	14		1	8.4	6	2	Hirchsprung Pu	2		4	3	3	3	3	1	1	4	0.36	0.55	3
149	2		1	4.7	1	1	herniotomy	2		3.5	2.5	2.5	2.5	2.5	1	1	4	0.65	1.27	2
150	2		1	4	2	1	DJ stenting	2		4	2.3	2.3	2.3	2.3	1	2	5	0.28	1.12	2
151	12		1	6.7	1	2	Hirschsprung f	2		5.5	3.8	3.8	3.8	3.8	1	1	3	0.3	1.37	3
152	12		1	7.5	1	1	herniotomy	1	Dimple	4.5	3	3	3	3	1	1	5	0.54	1.6	4
153	24		1	14	4	1	Urethroplasty	2		5.5	4.5	4.5	4.5	4.5	1	1	2	0.52	1.87	4
154	24		1	10	3	2	Cerebral Palsy	1	dimple	6	5	5	4.5	4.5	3	1	3	0.54	1.54	4
155	24		1	10	6	1	Adrenelectomy	1	Nevus	6.5	5.5	5.5	5.5	5.5	1	1	3	0.92	2.15	4
156		4	1	2	6	1	PUV Fulguratic	2		3.5	3	3	3	3	1	1	4	0.38	0.74	5
157	3		1	3.5	1	1	Herniotomy	2		3.8	3.5	3.5	3.8	3.8	3	1	3	0.3	0.9	2
158	24		1	10	1	1	herniotomy	2		4.5	3.2	3.2	3.2	3.2	1	1	4	0.37	1.74	4
159	4		2	4.6	5	2	ASARP, ARM	1	Dimple	4	2.8	3	2.5	3	1	2	4	0.3	1.3	3

0.8	0.12	0.68	1.49	1	1.5			1	
0.55	0.07	0.22	0.74	1	2.8	0.29	0.45	1	
1.24	0.09	0.51	1.73	1	2.8	0.65	0.46	1	
0.62	0.06	0.31	0.94	1	1.5	0.43	0.33	1	
1.18	0.07	0.77	2.26	1	3.8	0.49	0.6	1	
0.47	0.06	0.22	0.57	1	2.8	0.47	0.35	1	
0.55	0.09	0.25	0.77	1	2.2	0.33	0.13	1	
1.17	0.09	0.71	2.12	1	3.2	0.82	0.32	1	
1.04	0.09	0.45	1.52	1	3.5	0.68	0.38	1	
1.05	0.12	0.31	1.27	1	1.8	0.68	0.38	1	
1.1	0.12	0.69	1.96	1	4	0.74	0.3	1	
0.45	0.1	0.4	0.83	1	2	0.5	0.37	1	
1.04	0.12	1.08	2.13	1	2.4	0.56	0.51	1	
1	0.09	0.8	1.62	1	2	1	0.5	1	
1.26	0.14	0.47	1.97	1	3.5	0.68	0.79	1	
0.52	0.11	0.33	1.02	1	2	0.27	0.16	1	
1.04	0.09	0.32	1.44	1	2.5	0.44	0.36	1	
1.2	0.1	0.66	1.8	1	3.5	0.62	0.49	1	
1.38	0.14	0.48	1.84	1	2.5	0.68	0.63	1	
1.21	0.13	0.48	1.56	1	2.5	0.62	0.49	1	
0.99	0.21	0.36	1.09	1	1.5	0.71	0.43	2	3
0.91	0.14	0.45	1.28	1	1.5	0.55	0.37	1	
1.16	0.14	0.53	1.86	1	2.4	0.59	0.57	1	
0.64	0.11	0.57	1.22	1	3	0.63	0.45	1	
0.85	0.08	0.45	1.31	1	2	0.74	0.35	1	
1.07	0.15	0.2	1.75	1	3.5	0.68	0.66	1	
1.05	0.11	0.6	1.65	1	2.2	0.66	0.57	1	
1.47	0.12	0.64	2	1	3.5	0.82	0.5	1	
1.02	0.13	0.51	1.26	1	4	0.42	0.49	1	
1.22	0.18	0.98	2.06	1	4	0.62	0.69	1	
0.52	0.08	0.37	0.75	1	1.5	0.45	0.35	1	
0.67	0.08	0.14	0.72	1				2	1
1.58	0.1	0.31	1.74	1				1	
1.03	0.15	0.06	1.09	1				1	